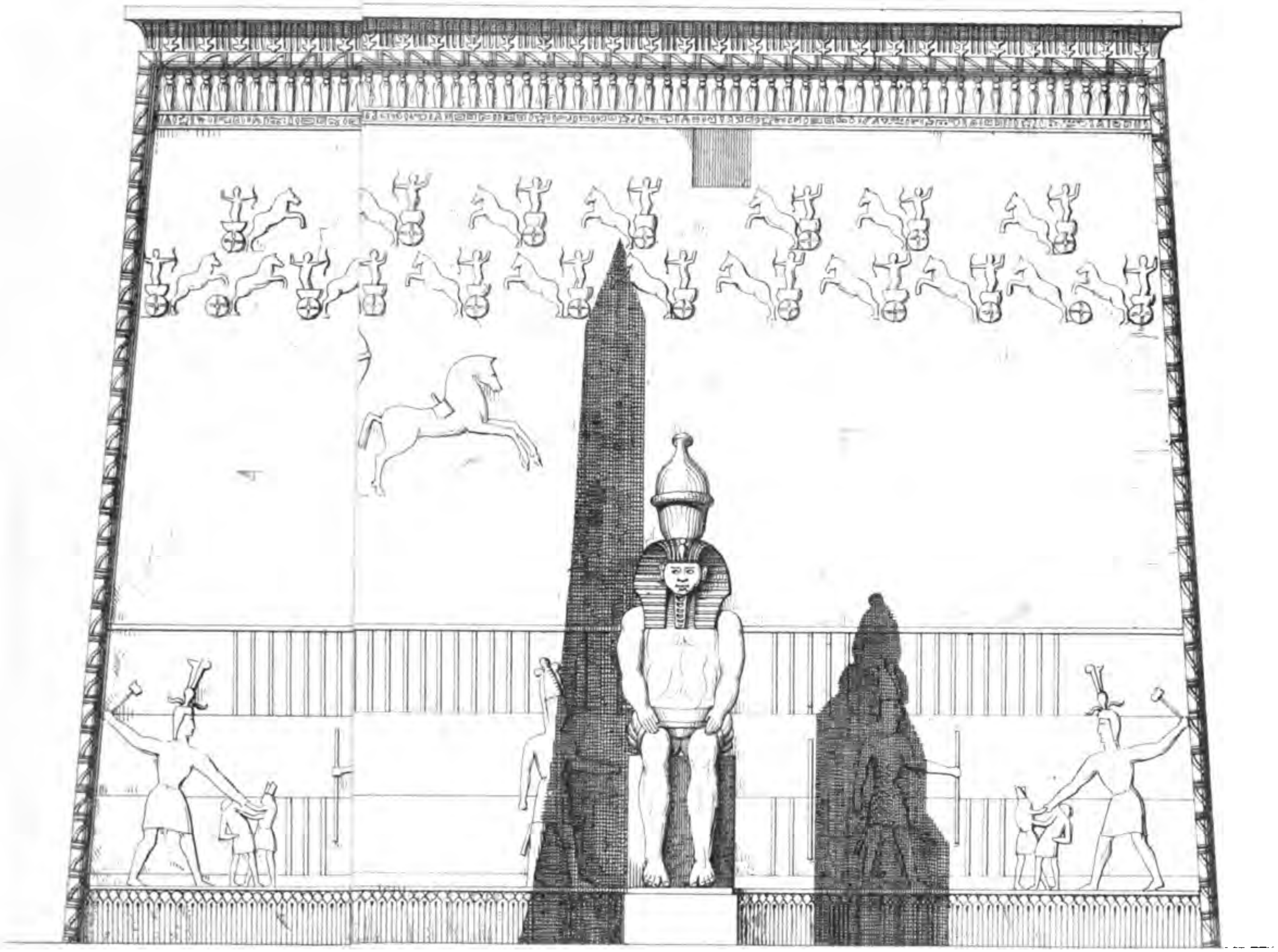
PLATE I.



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THE
CIVIL ENGINEER AND ARCHITECT'S
JOURNAL.

LECTURES ON ARCHITECTURE,

By Samuel Clegg, Jun., Esq.

DELIVERED AT THE COLLEGE FOR GENERAL PRACTICAL SCIENCE, PUTNEY, SURREY:

PRESIDENT, HIS GRACE THE DUKE OF BUCCLEUGH, K.G., ETC. ETC.

The Lecturer on Architecture proposing to deliver a course of lectures upon its history, monthly, in the Hall of the College, tracing the subject from its earliest origin to our own times, we have made arrangements for printing these interesting Lectures in *our Journal;* and we feel satisfied they will prove instructive, not only to the young student, but also to many of those more advanced in their profession.

We have the gratification of adding, that free access to these Lectures will be given to Members of the Institute of Architects, of the Institution of Civil Engineers, and to gentlemen being articled pupils in either of the professions, on application to the Reverend, the Principal of the College.

For the fees to the standing collegiate Architectural course, and also for that on Civil Engineering, we would refer our readers to the prospectus,—with our recommendation, that they personally make themselves acquainted with the system and means of instruction at an institution hitherto too little known, but which deserves public encouragement on account of the combination of theoretical and practical science which may be acquired simultaneously at this College.

Lecture I.——Introduction.—Egypt.

(*With an Engraving, Plate* I.)

History is universally allowed to be one of the most interesting and instructive studies that can occupy the attention of a thinking being. Not the mere chronicle of reigning monarchs and party factions; not the record of perpetually recurring war, with its consequent suffering and crime, but the history of the human race in its gradual development; of civilisation in its progressive and retrograde movements; of religion and commerce; of literature, art, and science: the history of all those things the cultivation of which have wrought the change from the ignorant savage, but little superior to the flocks and herds that clothed and gave him food, to the moral and intellectual man he was destined to become.

What can be more interesting than (standing as we do in the broad daylight of the 19th century) to contemplate the past,—to grope our way through the dark ages,—to pass in review the evening glories of Rome, the full blaze of noon in Greece, and the early dawn in Egypt and Assyria? In thus looking backwards, we find no art or science in which the genius of each succeeding age and country has so fully developed itself as in Architecture—the art, above all others, most useful and ornamental; adding at once to the safety and accommodation, and the delight and dignity of mankind. Architecture provides citadels for defence, habitations for private life, erects temples for worship, and theatres where we seek amusement; throws bridges over the otherwise impassable torrent, brings the refreshing stream from the distant mountain, raises monuments to our illustrious dead—and, in short, has its part in almost every comfort and luxury of life. Architectural remains present the only certain records we possess of several ancient nations: nor can we arrive at a better knowledge of a people separated from us by the interval of ages than by an examination of their buildings and monuments. Their temples speak to us of their faith and forms of worship; their palaces and courts of justice of their civil institutions; their triumphal arches and tripods and obelisks of their heroes and benefactors; their dwelling-houses of their domestic life; and their places of public assembly and amusement of the degree of civilisation and refinement to which they had attained. Under another point of view, also, the student will find himself well repaid by the study of the History of Architecture—*nothing* can tend in a greater degree to mature the judgment and refine the taste. Surely, in preparing ourselves for the practice of any art or science, and in order to carry it still farther towards perfection by our own endeavours, we ought to obtain a complete knowledge of those inestimable treasures with which the taste and genius of our forefathers has endowed us. But if we would really *learn*, we must approach this, like every other study, with a mind free from hastily-formed opinions, and unfettered by prejudice; we must be willing to admit excellence wherever it exists, and to perceive beauty wherever it is to be found, as well as to detect the barbarous and meretricious. We must recollect, in our examination of different styles, that no original forms were arbitrary or accidental; that wherever the manner of construction is suitable to the material—wherever the style of architecture corresponds with the climate, and is adapted to the sentiments and manners of the nation and of the age—wherever it constitutes in its principal forms and in its details and ornaments an harmonious whole, rejecting everything inconsistent with and foreign to itself, there we may find something to learn from and to admire: nothing is to be condemned but what is inharmonious and unsuitable. These principles will assist in forming a judgment on the works of all ages and nations: bearing them in mind, we shall easily perceive where a style has been borrowed—where it has owed its origin to a different climate and different circumstances, by the character of unconnectedness and unsuitableness it is sure to retain; until some artist of preeminent genius steps in, and successfully forms out of the mass of collected material, a new, national, and consistent style of building.

What can be more sublime than the monuments of old Egypt, where, by simple grandeur of outline and sculptured symbol, a nation in the infancy of the world was struggling to express the childlike earnest veneration for the unseen and unknown around and about it?—or what more ludicrous than a miniature pylon in the crowded thoroughfare of a great city, or a dromos of minute sphinxes keeping watch over the door-scraper and snug entrance-hall of a retired citizen's suburban villa? What could be more beautiful than the glittering shafts of Pentelic marble, rising from some tall cliff, the landmark of the Greek adventurer on his homeward way, or gleaming in the sunlight from amidst the consecrated grove?—or what more unsuitable than an imitation of such a temple transplanted into the damp and foggy atmosphere of England, and misconstructed into doing service as a dwelling-house, with its portico to obstruct the scanty light, and low-pitched roof to lodge the rain and snow? Can anything be more glorious, more significant than the Gothic cathedral, with its flowing lines and multiplication of parts, leading the mind onward to thoughts of immensity and infinity; and shaft upon shaft, arch and tower and pinnacle rising for ever upwards, like the aspiration of the Christians?—or anything more appropriate to the spirit of the age than the stronghold of the feudal baron, with its battlements and watch-towers, the terror or protection of the surrounding district? But what shall we say of a cottage in the pointed Christian style, perhaps with the addition of a row of chimneys *à la Cinquecento*?—or of a castellated mansion, in every other respect probably, the very beau ideal of peace and security?

By the study of the History of Architecture, both excellencies and defects become more evident, so that I would dwell upon it not merely as an *engaging study*, but as one of the highest practical importance, both to the architect and amateur. It is interesting to find the high estimation in which the arts were held in ancient times. During the intervals of peace, the spoils of war and the thoughts and energies of rulers and people were dedicated to the adornment of the beloved native land.

In Egypt, the profession of artist was considered one of such importance, that no illiterate person was allowed to exercise it. Agamedes and Trophonius, princes of Orchomenes, in Boetia, received from their countrymen an apotheosis, in honour of their skill in the mechanical arts. And the Etruscan lucumones, or nobles, were not only the senators, and generals, and priests, but also the astronomers, engineers, and architects of their country. Wherever architecture has been encouraged, it follows naturally that painting and sculpture, and all the decorative arts, have flourished at the same time, and have been held in equal estimation.

Though we may imagine buildings to have been amongst the first wants of mankind, yet, from the probable slightness of material of those primitive constructions, our oldest architectural remains must date many centuries subsequent to the wooden or mud huts of the early races. In tracing the first steps in the art, therefore, we are left to mere conjecture. As we must suppose the first men living in a warm climate, we may also imagine that little more was necessary to them than what Nature had bestowed—the groves for shade and shelter, and the spontaneous productions of the soil for food: thus they lived without care or labour. But as mankind increased, it was necessary to disperse to procure a sufficiency of food; and colonies from the primeval tribe, wandering to colder or hotter regions where Nature was less liberal in her gifts, they were forced to think, to invent, to labour, in order to provide for their subsistence. We may suppose these early colonists divided into three classes—Hunters, Shepherds, and Agriculturists.

1st. The *Hunter*, leading a precarious and solitary life, dependent upon his own individual exertions, and frequently changing his haunts in following his prey, would, when wearied by day, content himself at night with a cave, or any other natural shelter, where he might prepare his food and recruit for the next day's toil. This is the rudest state of existence; nor do we find the Indian or New Zealander in a much greater state of civilisation than their most remote ancestors may have been.

2nd. The *Shepherd*, living a patriarchal life in the midst of his flocks and herds. As it was necessary for him to seek the open plain for pasturage, he could not have recourse to the rocks or forests for shelter; and as his was a wandering life, moving off to new districts as the supply of food was exhausted in the old, neither could he build himself a fixed habitation: therefore, we universally find a shepherd people living in tents—which, when required, could be removed with all the goods and chattels appertaining.

3rd. The *Agriculturists*—and it is to this class we must look for the first institutions of social life, and consequent progress of civilisation. The agriculturist was necessarily fixed to one spot; labour was divided, the industry of each became beneficial to the whole. As the community increased, a small portion of the population was found adequate to the tillage of the soil; the remainder must therefore devise some other method of profiting by their time and labour: man's energies were thus first called forth to create and supply artificial wants; members of society became dependent on each other, rights of property were acknowledged, exchange of commodities effected, and laws were framed to protect the weak against the strong. The increasing wealth of the community demanded additional means of safety; not only were houses required for the people, and buildings in which to store up the grain, but walls must be erected to protect the infant state from the incursions of their less industrious neighbours. A chief or king was chosen to enforce the laws, direct the councils, and lead the warriors; and as all were occupied with their several avocations, a priesthood was set apart to watch over the interests of religion, and offer up sacrifices to the gods: then altars or temples were erected in honour of the presiding deity, and a palace in which the chosen leader might reside with becoming dignity. Other habitations naturally multiplied around the altar and the palace: and thus the first cities originated. Frequently, in the earliest times, the king was at the same time high-priest; and then we find, as in Egypt, the palace and temple in one, and the hall of justice an essential part of the edifice. Gradually as one city arose after another, communication was opened between them by land and sea, and roads and harbours were constructed. Some united together under one chief for mutual protection, others were offshoots from the mother city, always acknowledging her as their metropolitan: thus kingdoms were formed, and civilisation progressed—not only in time of peace, but in this infant state of society even more rapidly in time of war,—the conquerors adding the arts and learning of the conquered to their own previously acquired knowledge. It is this transmission and diffusion of ideas that makes it so difficult to point to the exact origin of any art or science, and has caused so many dissertations, whether to Egypt, to Phœnicia, or to India, we owe the first advance in the march of human progress. Letting this question rest, I prefer to speak of Egypt first, as we have more ancient, authentic, and copious records of this, than of any other nation of antiquity.

Egypt will always claim a high place in our interest. To quote the words of Mr. Sharpe, after speaking of the histories of the Jews, of Greece, and of Rome, he says: "After these three histories, that of Egypt may certainly claim the next place, from the influence which that remarkable country has had upon the philosophy and science of the world, and from the additions it has made to the great stream of civilisation; which, after flowing through ages of antiquity, and fertilising the centuries through which it has passed, is even now, in its present fulness, still coloured with the earliest of the sources from which it sprung. Architecture and sculpture, the art of writing, and the use of paper, mathematics, chemistry, medicine, indeed we might add legislation, and almost every art which flourishes under a settled form of government, either took its rise in Egypt, or reached Europe through that country."

Before examining the Architecture of the Egyptians, it is necessary cursorily to notice those peculiarities of situation, climate, and habits of thought, from which it took its rise. Egypt being little more than a strip of country formed by the annual inundation of the Nile, in the midst of a sandy desert, bounded by rocks, was so far isolated and protected by the nature of its situation, as to be less subject to those perpetual invasions and inroads that form so prominent a part in the history of other countries. Egypt could only be attacked through narrow and difficult passes from Ethiopia, Syene, or Arabia Nabatœa: consequently, we find the same dynasty governing many hundred years. Manetho give a list of native Thinite, Memphite, and other kings, includi sixteen dynasties, extending over a period (if we may believe hi of nearly 4,000 years before the invasion of the Shepherd Kings. During this time, the arts and sciences had made greater progress than in any other country. The soil and climate also had great influence in forming the character of the people. The continual struggle to preserve the valley of the Nile from the incroachment of the desert—or, as they expressed it, the perpetual conflict between the god Osiris (who annually arose from his bed in Philœ, to scatter blessings over the land) and the evil spirit Typhon—called forth all the energies of the people, and long preserved them from that enervating spirit of luxury and sloth, to which the downfall of so many nations may be traced. The peculiarities of their country, no doubt, also tended to make them the serious, devout people Herodotus describes. He says, "they are very religious, and surpass all men in the worship they render to the gods." They saw their land fertilised every year by the hand of Providence—the waters rushing down from an unknown source, and again, in due time, receding; they beheld the sun sinking, night after night, behind the unexplored and silent tracts of the great Lybian desert; and there arose within them an awful sense of the divine and mysterious, a haunting consciousness of the impotency of man compared with the *unmentionable One*,* to whom supreme homage was paid. The Nile was the great source of the prosperity of the country in another way; it was the longest inland navigation known to the ancients, and became the route by which the wealth of India was exchanged for that of Europe; thus pouring a continual stream of riches through the land of Egypt. So early were the advantages of the Nile navigation appreciated, that villages were thickly scattered over its valley, while the neighbouring countries of Arabia and Syria were only scantily peopled by a few herdsmen. The population of Egypt went on rapidly increasing under these favourable circumstances, and in the reign of Amasis II. (566 B.C.), it amounted to seven millions of inhabitants.

We do not possess many legends or traditions respecting ancient Egypt;—other nations boast of their poets and historians; but here they carved the names and deeds of their kings and heroes in stone, and painted the history of their private life on the walls of their tombs: so that if we have less of poetic fiction, we have a more certain basis of reality.

The name of This occurs as the first Egyptian city; then we have the names of numerous kings of Thebes and Memphis: of these we have no certain data; we only know that they carry us far up the stream of time; and when Abraham visited Egypt (about 1600 B.C.), he must have found the country already in a high state of civilisation. Next reigned the abhorred Hycsos, the Shepherd Kings—those "men of an ignoble race," as Manetho calls them; after their expulsion, a succession of native sovereigns extends over a period of 500 years. During this time, Thebes was the chief city, and Egypt surpassed every country in the known world in riches and power. 1400 B.C., Upper and Lower Egypt were united under Thothmosis II., and Queen Nitocris; and in the reign of Amnopth II. (1300 B.C.), Moses was educated in all the learning of the Egyptians. In the following century (1200 B.C.), we arrive at the era of Rameses the Great, the Augustan age of Egyptian history; the age in which native arts and architecture was brought to the greatest perfection. The following 500 years, from the time of Shishak, the conqueror of Rehoboam, the Thebaid sunk to the rank of a province, and Memphis once more became a capital city. The wealth and population of the people continued to increase, —but patriotism and virtue had declined. Instead of adding to the magnificent monuments of their predecessors, the monarchs now bestowed their riches in hiring Greek mercenaries to support their throne. It was in this period that the Greeks began to seek information from the learned Egyptians; and the illustrious names of Thales, Solon, and Pythagoras, occur amongst those of the travellers of that age. Mercenary aid can do little when native valour fails; and Egypt fell, under Cambyses (523 B.C.), never to rise again in her pristine glory and independence. The country passed successively under the yoke of Persians, Greeks, and Romans, though nominally still governed by independent princes. As long as native sovereigns remained to her, however (though only in name), the style of architecture altered but little: but soon after the reign of Cleopatra, it was merged, together with the kingdom, in that of all-conquering Rome.

In the general forms of their architecture, the Egyptians seem to have imitated the angularity of the bare rocks and drifted sand-heaps, and the long horizontal lines of the desert plain. Their building materials consisted almost entirely of brick and stone; the indigenous trees being principally palm, sycamore, and acacia (the former, deficient in strength and durability—the latter, too scarce to be used to any great extent in their buildings), served for household furniture, mummy-cases, &c. Wood was so highly prized by them, that cedar, ebony, and other rare woods, formed part of the tribute imposed on conquered nations; and East Indian mahogany was imported amongst the most valuable productions of that country.

Brick seems to have been the first material used, probably before the art of quarrying stone was known; it was afterwards employed in constructing walls of inclosure, and in buildings where cheapness and expedition were greater considerations than durability. Egyptian bricks were generally crude, mixed with straw and dried in the sun; kiln-burnt bricks were occasionally used in foundations, quays, the raised terraces on which the towns were built, or in any situation where they would be exposed to frequent contact with water. The crude bricks were about 15 inches in length, 7 inches in breadth, and a little more than 5 inches in thickness: this simple material was found to be peculiarly suitable to that dry, hot climate, where rain scarcely ever falls; and were further recommended by the ease and rapidity with which they could be made. The brick-fields afforded abundant occupation for numerous labourers; and the demand was so great, and the trade so profitable, that the Egyptian government took it into their own hands, and considerably increased the revenue by this monopoly. In order to prevent unauthorised persons from engaging in this manufacture, a seal, containing the name of the king or some other privileged person, was stamped upon the bricks before they were dried: numerous bricks, thus stamped, have been found at Thebes and elsewhere. According to Vitruvius, crude bricks should only be manufactured in spring or autumn, in order that they may dry slowly; those which are made in the heat of summer speedily dry outside, while the inside remains moist: the brick thus becomes defective, and easily gives way. He further observes, that bricks ought to have been dried five years before they can be considered fit for use, and that their having been so should be certified by a magistrate. If these rules originated with the ancient Egyptians, it is probable that the stamp before mentioned may also have been a warrant of the solidity of the bricks.

The boundary rocks on each side of the valley of the Nile, afforded abundance of stone for every purpose. Basalt, syenite, and porphyry for obelisks and statues, and limestone and sandstone for building, is found from one end of Egypt to the other.

An ancient Egyptian city must have presented a very different appearance from those of any contemporary nation, from the absence of the surrounding walls, that form so striking a feature in Asiatic and ancient Greek towns,—the isolated position of the country precluding the necessity of this mode of protection. In order to check the incursions of the Arabs, a boundary wall of crude brick extended from Pelusium along the edge of the desert by Heliopolis as far as the Ethiopian frontier at Syene, a distance of about 187 Roman miles: many vestiges of this great work are still remaining. Walls of inclosure surrounded the temples; but these walls, though sometimes as much as 24 feet in thickness, appear to have been less for the purpose of defence than of marking the boundary of the sacred inclosure.

The monuments of Egypt may be divided into six kinds:—1st, Pyramids; 2nd, Those enormous piles adapted to the threefold purpose of temple, palace, and fortification; 3rd, Structural temples, fortified and unfortified; 4th, Temples, partly excavated, partly structural; 5th, Monolithic and excavated temples; and, 6th, Tombs.

The pyramids of Cochome are not only the most ancient monuments of Egypt, but probably the oldest in the world. Manetho ascribes them to Venephres, king of This, in the 1st dynasty. The great pyramids of Geezeh were built by Sûphis, or Cheops, and his successor, Sensuphis, as it is supposed, about 1600 B.C. These enormous structures occupy each a square plot of about eleven acres: the largest is 728 feet on each side of the base, and about 500 feet in height. The pyramidal form seems to have obtained favour amongst all the nations of antiquity. We find pyramids in Assyria, in India, and among the remains of Central America. It has been suggested that the form may have originated from the old Mithratic worship, and have been symbolical of the rays of the sun. The pyramid may, however, have presented itself as the most enduring form, as well as the simplest in construction, enabling this ancient people to raise monuments on that gigantic scale after which they aspired; nor if we allow that whatever tends to create ideas of superior force and energy contains the elements of the sublime, can we deny this attribute to the pyramids and other marvellous works of the ancient Egyptians. He-

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* It was considered impious by the Egyptians to name the Supreme Being.

rodotus informs us that King Cheops put a stop to all other works until the building of his great pyramid should be completed; 100,000 men were unceasingly employed, and relieved every three months by an equal number, and that twenty years were occupied in its erection; he also gives us an account of the quantity of radishes, onions, and garlic consumed by the workmen (probably their only wages); on these were expended 1600 talents of silver, or, in our money, about eighteenpence a-year for each workman. This information Herodotus gained from the hieroglyphic inscription that still existed on the side of the pyramid in his day. There is now no doubt that the pyramids were intended as sepulchres. Queen Nitocris erected the smallest of the three near Memphis, and cased it with red granite from Syene. In the valley of Saggarah, thirty pyramids still exist, and there are traces of many more.

Both in the plain and on the heights above Thebes, are many remains of small crude brick pyramids, in one of which is the most ancient arch yet discovered—its date is given as 1540 B.C. The Egyptians, constant and inflexible in all that bore upon religious forms, observed in the construction of their temples the same immutable rules: these edifices, therefore, only differ one from another in size and extent. The principal characteristics of Egyptian architecture are vastness, simplicity, and angularity; forming a style so stupendous, and so calm in its massive grandeur, that these monuments above all others have been able to defy the ravages of time, and still strike the beholder with admiration and wonder. Inability to combine solidity with lightness, probably produced the massive exterior walls, sloping from the base upwards; but while the exterior had always a pyramidal form, the interior wall was vertical,—thus giving a greater thickness at the base than towards the summit. Another peculiarity is the profusion of columns which would necessarily result from the mode of roofing, the roofs being formed by huge blocks of stone stretching from column to column, always perfectly flat, and without pediment: therefore, when halls of great size had to be roofed, it could only be done by placing rows of columns in the interior, to support the horizontal blocks,—a method that injured the effect, and greatly interfered with the space.

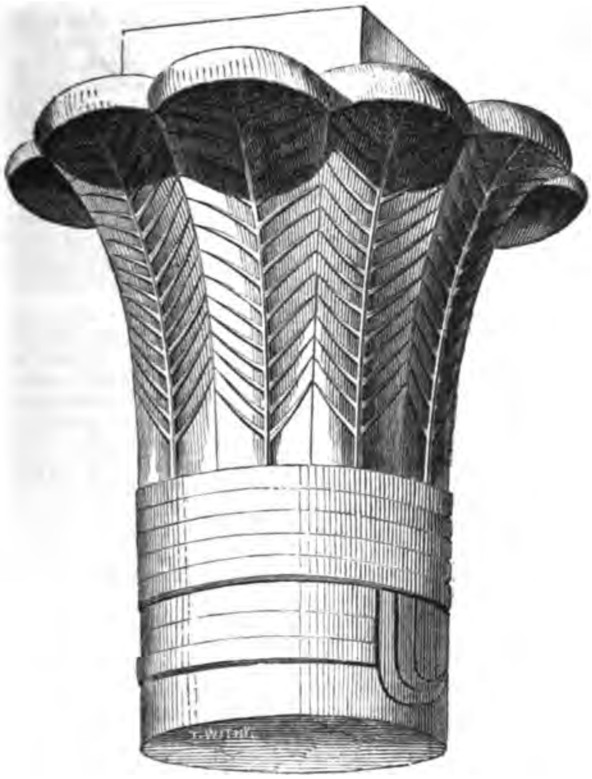
The great temples of Egypt were not like those of Greece and Rome—a complete structure composed of one order—but rather an assemblage of porticoes, courts, vestibules, galleries, and halls, united together within an inclosure: each one of these parts was generally independent of the rest, was ornamented by columns of a peculiar form, and in its dimensions had no reference to the other portion of the building. The sacred inclosure was surrounded by a wall (as before mentioned), and was planted with palms and flowering shrubs. From the entrance gateway to the first pylon was a paved avenue, called a dromos, ornamented with rows of sphinxes or colossi: from the first pylon we are led to another, and sometimes even to a third; these pylons were huge pyramidal towers in pairs, with a gateway between; these were the bulwarks and watchtowers. The entrance doors were elaborately decorated; and staircases were formed in the thickness of the gateway walls, leading to the flat roof of the tower; they ascended in a direct line, from one landing-place to the next, and each landing-place was lighted by small windows or loop-holes. The space between the pylons formed vast galleries or halls. After these we reach the pronaos, and sanctuary or adytum; frequently, also, there were chambers surrounding the adytum, serving as residences for those who had charge of the temple and the sacred animals. At the posticum there was sometimes another large hall, probably serving as a hall of justice; and Diodorus Siculus informs us that the sacred writings were kept in an apartment in the temple. The halls and vestibules were lighted from the top; the roof over the centre part was raised above what may be called the side aisles, the spaces between the necessary supporting blocks being left open, or filled-up by a stone grating,—thus producing a solemn twilight, which must have been both imposing and refreshing after the glare of the scorching sun and blinding sand. I must not omit to mention one great singularity of construction, which is, that the inner apartments of the temple regularly diminished in size: thus, the pronaos was smaller than the vestibule, and the adytum than the pronaos. The side walls gradually sloped inwards, the ascent of the ground was formed by shallow steps, and the descent of the roof concealed by massive transverse architraves; thus the sanctuary, to which the priests only were admitted, appeared to the worshippers not small, but distant. This plan is most strikingly apparent in the temple of Omboo.

The shafts of the columns are either polygonal or circular; it does not appear that the Egyptians had any fixed proportions. The columns were always massive, and those in the great hall at Karnac are 11 feet in diameter; owing to the buildings being so much choked up with sand, it is difficult to ascertain the exact height, but the loftiest columns (those of Luxor), probably do not exceed 56 feet. The polygonal columns are the most ancient; those of Beni-Hassan and Kalapshe may be of doubtful origin, though the shafts of the latter excavation have received a more undoubted Egyptian character from the stripe of hieroglyphics extending from base to capital in each shaft. The oldest purely Egyptian form resembles a bundle of reeds bound together with cords; the capital is formed by the bulging out of the reeds, as would naturally result from the pressure of a superincumbent weight; the shafts are compressed at the base, as if the reeds were more tightly bound.

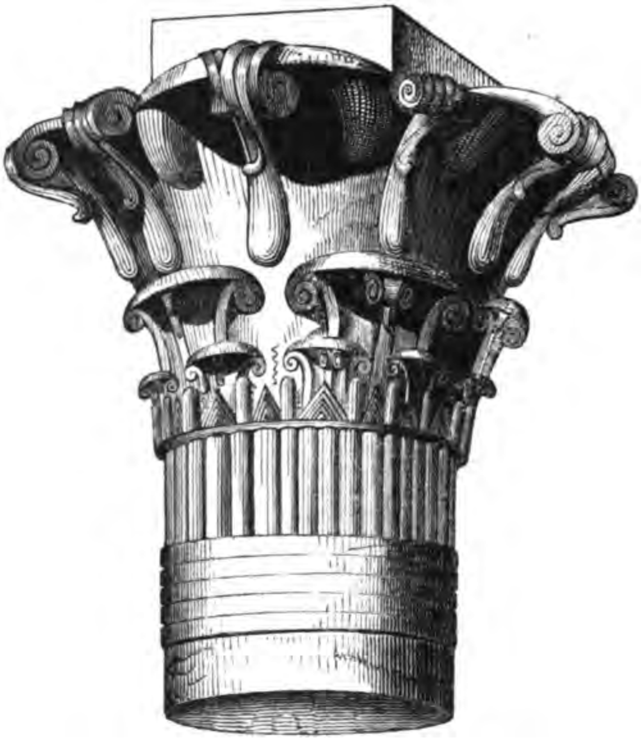
The capitals do not vary so much in form, as in ornament; they are generally vase-shaped, or present a graceful curve—perhaps imitated from the palm branch. These capitals are the first traces we discover of imitative taste, the decorations being exclusively copied from indigenous plants, and representing the delicate leaves and blossoms of the lotus, the palm, vine, or papyrus (as shown in the opposite page). Other capitals were surmounted by heads of the goddess Isis, supporting a miniature adytum, as at Dendarah and Philœ.

Isis Capital.

The capitals of the columns in a hall or gallery, though symmetrical in form, were frequently infinitely varied in ornament, as in the temples of Edfou, Esnèe, and Philœ. Though, on account of the accumulation of sand, the bases of the columns are no longer visible, it may be conjectured, from the narrow intercolumniations, that they either had none or stood upon a simple plinth, as in some of the excavations. The profile of the entablature is little varied; the general crowning member is a large bead and cavetto, as shown in the engraving of the pylon of Thebes. Sometimes the frieze is sculptured, sometimes plain, or carved with hieroglyphics.

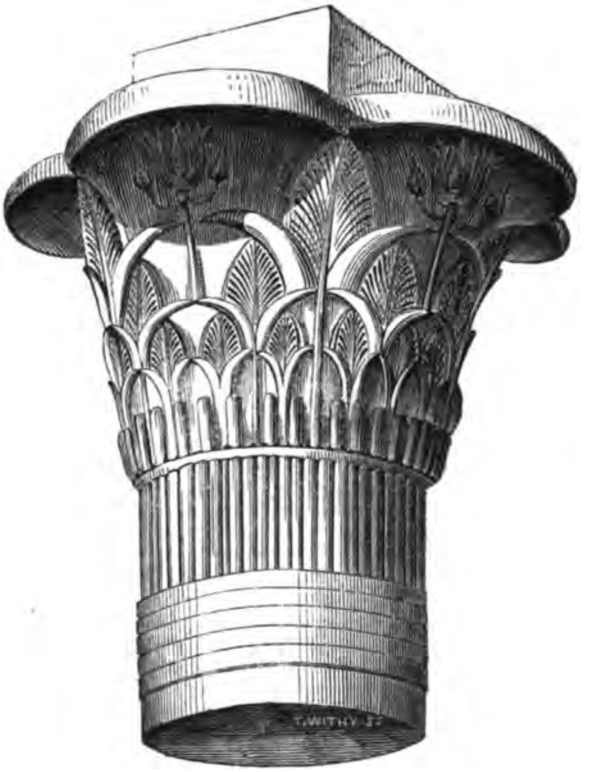


Palm Capital.



Lotus Capital.

Palm and Vine Capital.



Papyrus Capital.

The walls and roofs of the temples are frequently entirely covered with hieroglyphics and sacred symbols, carved in bas-relief and richly coloured. This mode of decoration was sometimes applied also to the exterior of the building, the pylons being covered with carving, as at Luxor. The adytum is the most elaborately ornamented; and here is found described the tutelary deity of the temple, the name of the founder, &c. The Egyptians seldom made use of ornament without a meaning: the winged globe, so constantly repeated above the doors and on the roofs, symbolised eternity or infinity; the triple rows of reeds on the cavetto (something resembling the triglyph) separated the ovals containing the names of the kings, builders, or restorers of the temple. The sculptured frieze was frequently formed by rows of the sacred asp and globe: thus they appealed to the devotional feelings of the people, or taught them a history in every decoration. Occasionally, the shafts of the columns were merely coated with white stucco,—and, to our great surprise, we sometimes find even the beautiful granite of Syene treated in a similar manner.

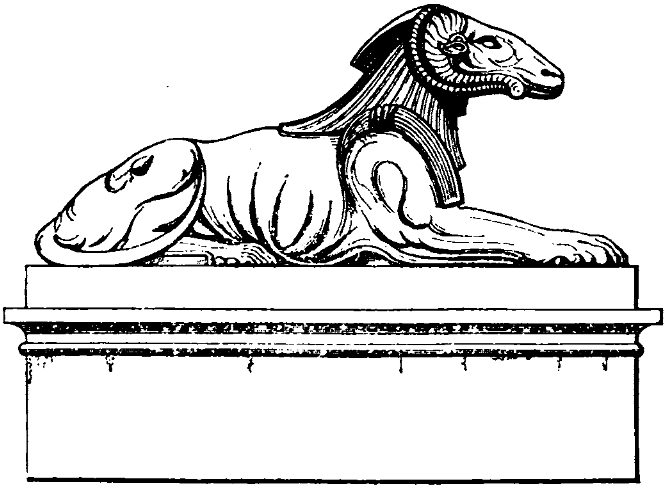
When sandstone was employed, it was necessary to cover it with a smooth, unabsorbent composition before painting. In painting, red, blue, and green was the favourite combination; when black was used, yellow was always introduced as a contrast. The reds and yellows were ochres; the blue, metallic, prepared from copper; the black, lamp-black; and the white, finely-prepared gypsum or lime: these paints were mixed with water and a little gum, to render them more tenacious.*

The Egyptians were well acquainted with the manufacture of glass and enamel: a chamber in one of the pyramids of Saggarah is lined with blue porcelain slabs, like Dutch tiles.

That the Egyptians had a thorough knowledge of the art of masonry is evident—the stonework in the interior of the great pyramid of Geezeh has never been surpassed in any age. The shafts of the columns were sometimes carved out of one solid block; but when formed of sandstone, were built in courses varying in number according to the height of the column—Pococke counted seventeen courses in one column. More than one kind of cement was used by the Egyptians: the mortar employed in building the great pyramid was lime mixed with sand. Occasionally, the stones were fitted one to another without cement; and in some cases where they have become partially separated, wooden toggles are observed.

It is singular, that in a country where so little rain falls, the architects should have been so particular in fitting the stones that formed the roof; but so attentive were they to this, that besides carefully cementing them together, the interstices were covered with a piece of stone let into a groove of about eight inches in breadth, extending equally on each side of the line of junction.

I have already noticed the discovery of the arch in the brick pyramid near Thebes; but the most common kind of vault in Egypt was formed by layers of stone projecting one beyond another, and capped by a horizontal stone at the summit: the inverted steps were afterwards hollowed out. In one or two instances, the great stones forming the roof have been placed on the supporting columns edgeways, instead of on their face, so as to give a sufficient thickness to allow of their being hollowed out, and thus forming a vaulted ceiling.



Crio-Sphinx.

There seems to be some doubt as to whether the Sphinx is of Egyptian or Assyrian origin: it occupied the same position in both countries—at the entrance of the palace or temple; and in both countries expressed the same meaning, being typical of the most perfect union of physical and intellectual power. In Egypt, it was used as the symbol of the king or governing power. The Egyptian sphinx was of three kinds—the Andro-sphinx, or human-headed; the Crio-sphinx, or ram's-headed; and the Hieraco-sphinx, or hawk-headed: they were all represented with the body of a lion, and a small figure of the king was occasionally placed between the paws. The great sphinx near Memphis was carved out of the solid rock, in the reign of Thothmosis IV., about 1300 B.C.; according to Pliny, it measured 63 feet from the ground to the top of the head, was 143 feet in length, and the head round the forehead 102 feet in circumference. An adytum, with an altar for sacrifice, was placed under the chin, so that the worshippers walked up the avenue formed by its huge paws; and the smoke of the incense ascended to the nostrils of the monster.

In their sculpture, as well as their architecture, the Egyptians were restricted to the same original forms by religious rules; it is therefore difficult to judge whether, if such had not been the case, they would have been able to delineate the human figure correctly. We know they could give the idea of action, from the animated groups in the paintings on the tombs. Nevertheless, the Egyptian statues have an effect of calm grandeur, and a serenity and benevolence of aspect, that cannot fail to excite a feeling of veneration, as they sit with their hands placed straight on either knee, peacefully looking out into space, and smiling upon the centuries as they have rolled by; or stand with folded arms, bearing the flagellum, as the inflexible judges of human deeds.

Thebes contained two great palace-temples—El Karnac and Luxor; the palaces of Medinet-Aboo, and the Memnonium or Rameseum, besides other great buildings, as the temple of Dayr-el-Bahree, built by Queen Nitocris, and that called the tomb of Osymandyas, where stand the osirides, improperly called caryatides: it is worthy of remark that these osirides do not sustain the entablature, but are merely attached to the supporting pillars.

Osiride.

The most ancient building is the palace-temple of Karnac; it was the work of many successive kings, and is now the largest and perhaps the most splendid ruin in the world. The wall of the sacred inclosure would appear to have encompassed an entire city, rather than one edifice. This stupendous structure was founded by Osirtesen I., upwards of 1600 B.C. It was enlarged by Queen Nitocris, who set up the two great obelisks in the court, each

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* The finely painted columns of Karnac, even now showing in their almost pristine beauty, were tinted in water colour.

92 feet in height. Thothmosis III. made several additions, which were carried on by his son, Amunothph II. (1321 B.C.), in whose reign the arts of painting and sculpture made rapid progress,—though in the columnar hall built by him at Karnac, with reversed cornices and capitals, we find a greater instance of caprice than of good taste. This palace-temple was enlarged and decorated by almost every succeeding monarch. To give an idea of the gigantic proportions of this edifice, it may be mentioned that the great hall of assembly is 329 feet in length, by 170 feet in breadth, and 85 feet in height, and containing 134 columns; the lintel of the doorway is formed of one sandstone block, 40 ft. 10 in. in length and 5 ft. 2 in. in depth and breadth. The walls of this enormous structure are 25 feet in thickness.

The neighbouring palace-temple of Luxor (Plate I.) was begun by Amunothph III. about 1300 B.C., and finished by Rameses the Great, nearly 100 years afterwards. Two beautiful obelisks, of red granite, bear his name, and give evidence by their hieroglyphics, cut two inches deep, of the wonderful skill of the Egyptians in sculpturing this hard material. This temple is only inferior in size to that of Karnac: the length of the colonnade leading to the court is 170 feet; then follows an area of 155 feet by 167 feet, surrounded by a peristyle, containing twelve columns on every side; this terminates in a covered portico, 57 feet by 111 feet, supported by thirty-two columns. A dromos (not less than a mile in length) of six hundred crio-sphinxes, raised on a causeway far above the level of the Nile, connected the palace-temples of Karnac and Luxor, and formed the main street in the eastern district of Thebes. Another great dromos—called in some papyri found at Thebes, the "Royal street"—crossed the city in a westerly direction, communicating with the opposite bank of the Nile by means of a ferry. The soil of the desert was paved with sandstone blocks, as a foundation for the dromos.

The palace sometimes called the Memnonium, but more properly the Rameseum, was built or completed by Rameses the Great; this building, and also the palace of Medinet-Aboo (built by Rameses III., 1100 B.C.), do not seem to have been used as temples, but probably united the citadel with the royal residence. The celebrated *Pair*, called the Memnon statues, measuring each 60 feet in height as they sit, guarded the entrance to the dromos of the Rameseum; the rest of the avenue was formed by numerous pairs of colossi, nearly as large, but whose fragments now strew the ground.

The city of Memphis has ceased to exist. The temple of Pthar, the residence of the sacred Apis, and all the other great buildings with which it was adorned, have been completely buried or destroyed. Diodorus Siculus informs us that with its suburbs Memphis had a circuit of upwards of 16 miles: but now it presents nothing to the eye of the traveller but a sandy plain, an overthrown colossus of Rameses II., a few fragments of granite, and some foundations. How have the mighty fallen!

Amongst the numerous temples erected in Egypt, none are more interesting than those adorning the sacred island of Philœ. This island rises majestically with its monuments in the midst of the river Nile, above the first cataract, and was believed to be the burial-place of Osiris: "By him who sleeps in Philœ," was the Egyptians most solemn oath. The island is entirely surrounded by a wall, marking it as a sacred inclosure, and must have been as enchanting from the beauty of its site, as imposing from the magnificence of the temples with which it was covered. Numerous pylons, porticoes, columns, and obelisks yet remain, and the hypæthral temple, or bed of Pharoah (as it is sometimes called), is but little injured by time. Elegant and lofty columns, with capitals sculptured in various forms, support the entablature; two opposite doors, with broad imposts in the form of pilasters, afford ingress and egress; and the sides of the building, instead of being entirely inclosed, have the intercolumniations filled in with low walls or panels, to about half the height of the columns: these panels are finished with the usual bead-and-cavetto moulding. All the buildings on the island are covered with sculpture and painting, even to the shafts of the columns.

The Ptolemaic temples of Edfou and Esnèe deserve notice, from the exquisite beauty and finish of the carving and stonework. The former also possessed great strength as a fortification: the lofty portico (like that of Dendarah) is much higher than the body of the temple, and the narrow gateway of the pylon is the only opening in its massive walls. The city of Apollinopolis, where this splendid structure was erected, was situated on an eminence overlooking the river and the valley,—the great pylon was doubtless intended to command the whole.

Many of the smaller temples, or those in the neighbourhood of larger fortified temples, were without pylons, the principal entrance being through the portico; several have a peristyle, as those of Elephantine, Ermopolis, and others.

Of those temples partly structural and partly excavated, like that of Dahr-el-Bahree, it is needless to say more than that the adytum was carved out of the rock, while the vestibule and pylon were built.

We now come to the wonderful monolithic and excavated temples. There are monolithic temples both at Buto and Saïs. The temple, or rather adytum, or shrine, at Saïs, was intended by Amasis to adorn his great temple in that city. It is said to be a 60 ft. cube, carved out of one block of granite. It took 2,000 men three years to convey it from the quarries of Esouan, a distance of 700 miles. It stands in front of the temple. There is a tradition, that as the men were about to move it onwards to its intended destination *within* the temple, the engineer heaved a deep sigh, which so affected the king with the idea of weariness, that he commanded the work to cease: and the shrine remains as it was then left to this day.

It has been supposed that the temples and tombs carved out of the rock were the earliest attempts of the architect; but this seems a mistake, so far as either Egypt or India is concerned. These excavations afford a clear proof of their derivation from structures, in the architrave reaching from column to column—taken from the beam supporting the roof: this feature is totally at variance with the nature of a cave; and no further evidence can be necessary, as the imitation must be subsequent to the thing imitated.

The temple of Aboo-Simbel is in Nubia, on the west bank of the Nile, and belonged, with so many other stupendous works, to the reign of Rameses the Great. It was discovered by Burckhardt in 1813, and afterwards further explored by Belzoni. It is hewn, together with its colossi, in the hard gritstone rock. The four colossal figures in front (only one of which has been entirely cleared of sand) represent the great founder, Rameses; they measure each 70 feet in height, and 25 ft. 4 in. across the shoulders; the face is 7 feet in length, and the ears 3 ft. 6 in. On the front of the thrones, female figures are carved, supposed to be intended for his wife and children. During the execution of these colossi, where defects in the stone were discovered, they were filled-up with mud and straw moulded to the required form. The adytum terminates 200 feet from the entrance, and there four more colossal figures are seated, side by side, in the dim light.

Another smaller excavated temple exists in the immediate neighbourhood, dedicated to the goddess Athor: space will not allow me to enter upon the description of this, Garf-Hoseyn, and other wonderful excavations with which Egypt abounds.

The importance the Egyptians attached to the preservation of the body after death, probably first induced them to seek a place of sepulchre in the neighbouring rock, where security would be found against damp and other destroying influences. As these sepulchres increased in number, as year by year the population of the dead more and more exceeded that of the living, the inhabitants of the cities below would be led to think of the brevity of mortal existence, and would be impressed with the necessity of preparing a permanent home in the everlasting rock, against the time when they should be called to leave their transitory abode in the Nile valley. It was the profitable business of the priests to prepare these tombs; they frequently excavated them on speculation, selling them at a high price to those who had not the means of commencing a sepulchre early in life, as was the custom among the wealthy. The priests, therefore, took advantage of the natural feelings of the people, and in every way fostered and encouraged their passion for expensive and elaborate tomb decoration.

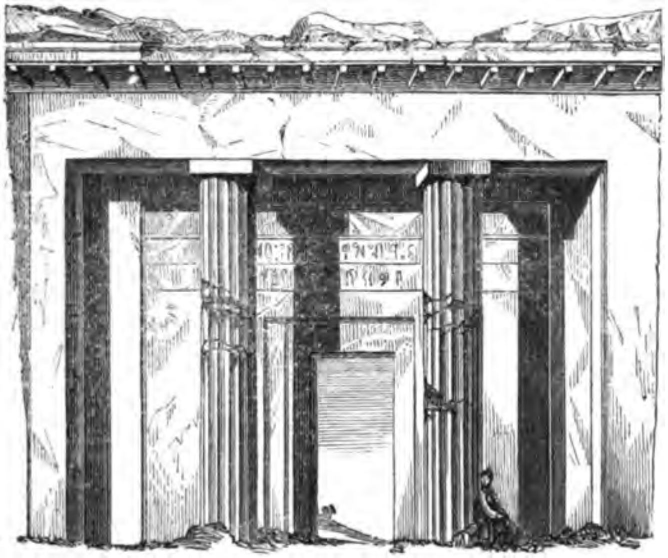
Wherever an Egyptian city arose, we find a nicropolis in the neighbouring Lybian or Arabian mountains. These tombs consist of vestibules, halls, galleries, and chambers, differing in number and extent according to the wealth of the occupant, whose name, rank, and mode of life, was illustrated on the walls; they had all square doorways, sometimes plain, sometimes with a richly ornamented façade. Frequently the entrance to the tomb was closed with solid masonry, but in others the outer chamber appears to have been used as a private chapel; and many had gardens planted in front, where the flowers were tended by the hand of some faithful mourner.

Between three and four miles from the river, in the immediate vicinity of Thebes, is a tortuous path, formed by a natural cleft in the rock: this leads to the celebrated valley of Biban-el-Moluk —the valley of the Tombs, where the great Theban kings have found their last resting-place. Many of these tombs remain unexplored, but those which have been opened are sufficient to attest the wonderful labour and skill, and the vast expenditure, lavished on their preparation and adornment.

The tomb of Amunothph III. is one of the most extensive of the royal sepulchres: it descends into the solid rock 320 feet in horizontal length, and its perpendicular depth to the place where it is closed by the fallen rock is 180 feet. In some of the inferior chambers it is probable members of the king's household may have been buried.

Another richly decorated tomb is that of Oimeneptha, opened by Belzoni: in a small vaulted chamber beyond the third and largest hall was discovered the alabaster sarcophagus now in Sir J. Soane's museum.

In the reign of Osirtesen I. (about 1650 B.C), were excavated the beautiful grottoes of Beni-Hassan, near Antinöopolis, the polygonal columns of which have been supposed to be the original of the Doric; these columns are 3 ft. 4 in. in diameter, 16 ft. 8½ in. in height, and have 16 faces, each about 8 inches in width; these faces are slightly grooved to the depth of about ½-inch, thus suggesting the idea of fluting: a simple abacus forms the capital. Two columns supporting an entablature projecting from the rock, out of which it has been carved, completes the façade. Upon the architrave a sort of dentel is sculptured; the cornice is too much broken away to allow of a decision as to whether it had the Egyptian or Doric character. A beautifully-proportioned doorway forms the entrance, the imposts and lintel of which are covered with carved hieroglyphics. On the lintel the following words have been deciphered: "A good house, food, and drink—bread, geese, cattle, perfumes, as offerings to the General, Nahride Nevothph, son of Dgiok." The principal chamber of the tomb is of a square form, about 30 feet in length and breadth. Two longitudinal architraves, each supported by two columns, similar to those on the exterior, divide the ceiling into three parts, each division being vaulted and decorated with stars on a blue ground: the basement and architraves are covered with hieroglyphics, coloured green on a red ground; and the walls are adorned with paintings representing the daily habits of Egyptian life, and, it is to be supposed, of Nahride Nevothph in particular. The fancy of the artist was allowed greater play in the tombs than in the temple, and we frequently find ornamental patterns very similar to those in use up to the present day. There are several other grottoes at Beni-Hassan, in one of which are reed-shaped columns; another has polygonal columns with plain sides.


Beni-Hassan.

Although the Egyptians expended so much money and labour in the preparation of their tombs, they were by no means negligent in providing for the comfort and luxury of their houses. From the amusingly detailed drawings they have left us, we have acquired a closer insight into the homes and manner of life of the Egyptians than of those of any other ancient nation. Diodorus Siculus tells us that the Egyptians originally built their houses of reeds. This may probably have been the case; but as brick-making was so early an invention, the reed houses were mostly soon confined to the lowest classes; and this may be the reason we find no representations of them on the tombs. The houses there delineated are of crude brick, as are found in the ruins of the Alabastron and elsewhere, and were covered with stucco.

One of the houses painted on a Theban tomb represents a square inclosure, to which ingress is gained by doors on opposite sides; the door to the left leads into a garden, where is a vine-arbour, and four trees. Beyond the garden is a courtyard, where, in several tiers, bread and meat, &c. is set out in the air in vases. On the right of this court is a gallery or passage, with a large window: then follows the house, with the entrance-door to the right. This house consists of two stories; two rectangular windows are seen with light and elegant imposts and architrave, variously ornamented and painted; the window-shutters are perforated, so as to admit the air and moderate the light. Above the second story is a terrace, with a roof supported by columns. A cornice runs along the side of the house as far as the entrance-gate, supported at each end by a pillar in the form of a stalk of the papyrus, with a square abacus.

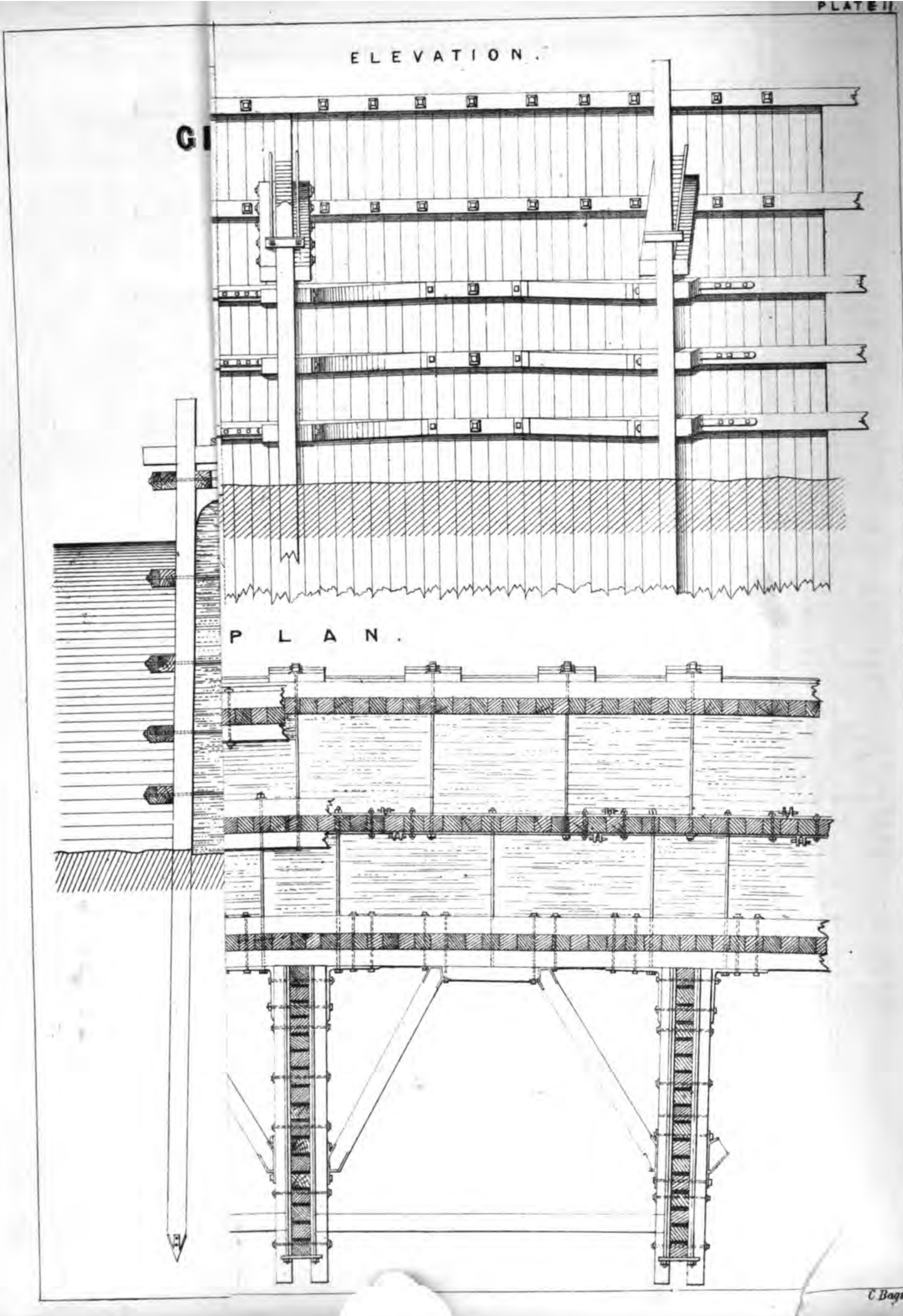
Another house is represented in the midst of a beautiful pleasure garden; by the side of one of the walls flows the river, shaded by a row of tall trees. From this walk an alley leads to the entrance gate; from this an avenue of trees conducts to a smaller gate, opening to the vine-arbour. The garden is laid out in walks or alleys, some of which lead to tanks of water surrounded by little verdant plots, on which vases containing plants are placed; in the tanks the lotus is growing and water-birds are disporting themselves. Here are also two small pavilions or summer-houses, surrounded by a balustrade. At the end of the garden, behind the vine-arbour, stands the house, which is entered by two doors; two elegantly decorated windows give light to the ground-floor; above are three stories, the upper one finished with a cornice, on which is placed three vases containing papyrus plants. The columns at the entrance-door were on festive occasions ornamented with ribands and banners: the name of the person to whom the house belonged was painted on the lintel or imposts of the door.

The rooms were usually arranged round an open court, or on either side a long passage; and in the court was generally a mandara, or receiving room for visitors. The ground-floor was chiefly used for store-rooms. The walls of the rooms were stuccoed inside and out, and variously ornamented with painted devices. The doors were frequently stained to imitate rare woods; they were sometimes single, sometimes folding, turning on metal pins and secured within by a bar or bolts of bronze. The floors of the rooms were either of stone or composition; the roofs formed with rafters of the date-tree, laid close together, or apart when transverse layers of palm branches or planks were added. Occasionally the ceilings were of crude bricks and vaulted. Sometimes, instead of a covered terrace, the house was surmounted by a mulquf, or wind conductor, such as is seen at Cairo at the present day. In some instances, part of the house was raised above the terrace as a tower, and was ornamented with battlements, in the form of half-shields. Each house had its granary, sometimes separated from it by an avenue of trees. We may judge how much trees were valued in that country, by the careful manner in which they were tended: each tree was surrounded by a low wall, to protect it from the cattle or other injury, with holes bored to admit the air.

The streets in the towns seem to have been regularly laid out, without the mixture of large houses and hovels, so usual in eastern cities. As is generally the case in hot climates, the streets were narrow, only the principal ones admitting the passage of a chariot. The houses of the lower classes were connected together, so as to form the continuous sides of the street; some of these small houses consisted merely of a court, and three or four store-rooms on the ground-floor,—with a single chamber above, to which a flight of steps led from the court. The upper chamber was so small and inconvenient, that it could scarcely be used for anything but an occasional shelter from the heat of the sun, or a place from whence the master could overlook his household; as Sir Gardiner Wilkinson remarks, it calls to mind the proverb: "It is better to dwell in a corner of the house-top, than with a brawling woman in a wide house." The shops were either open stalls similar to those in an eastern bazaar, or else mere booths in the public thoroughfares. The Egyptians possessed also extensive villas with orchards, vineyards, and pleasure grounds. Some of the larger country mansions had pylons and obelisks at the entrance, like small temples.

In contemplating the vast structures raised by the ancient Egyp-

PLATE II.


ELEVATION.

PLAN.

C. Bagster

tians, we are at a loss to conceive how a people comparatively ignorant of the mechanical arts could have achieved such gigantic works. Though it is probable they had contrivances either unknown to us, or now considered as comparatively new inventions, yet from all we can learn from written history, or from their own sculptured records, it seems that they depended more upon time and manual labour, than upon those arts by which modern undertakings are so much facilitated. It is remarkable that while the Egyptians have left us such minute and copious details respecting their customs, trades, and manufactures, any notice of engineering works is extremely rare: this may probably have been owing to its having been under the direction of the priests, and kept as a mystery. In a bas-relief we see a seated colossus which is being moved; ropes are fastened to every part of the figure, and are then gathered into one knot, to make the pull equal; and numerous strings of men are hauling it, the engineer standing on the knees of the figure, directing their movements. In another bas-relief we see oxen employed in drawing a stone.

We are told that in building the pyramids, in order to bring the stone from the boats on the Nile, a causeway was formed, 1000 yards long and 50 feet high, and this was probably raised as each successive course of stones was added,—so that each stone was rolled up this inclined plane to its place. If a huge stone was to be placed on the top of a wall, it was dragged up an inclined plane of sand to its destination. We have an account of an obelisk 80 cubits in height, that had been made in the reign of King Nectanebo; this the king Ptolemy Philadelphus wished to set up in Alexandria, in honour of his sister. To this effect, Satyrius, the architect, is said to have dug a canal to it as it lay on the ground, and to have placed under it two heavily-laden barges. As the barges were unloaded they floated higher, and thus raised the obelisk from the ground. Unfortunately, we are not informed how he afterwards proceeded to set it up in its destined position.

In quarrying stone, wedges were used, either of metal struck with a mallet, or of dry wood, which, when moistened, split the stone. We have no reason to suppose that free labour was *not* employed, but we know that criminals and prisoners of war were sent to work in the gold mines; and those guilty of misdemeanour may also have expatiated their fault in the quarries. There exists an inscription at the quarries of Gertessy, in Nubia, "I have now dragged 110 stones for the building of Isis at Philœ," which would seem to indicate a penance performed.

The Egyptians must have been well versed in land surveying, levelling, and various branches of geometry, as well as in many operations requiring mathematical science. That they were early skilled in forging metals and polishing stones, their works remain to prove; the art of gilding was known in the reign of Osirtesen I. (1650 B.C.) We have no record of the discovery of the art of manufacturing steel; and from the speedy decomposition of iron and steel, few tools can be expected to remain: but we cannot examine the deep and sharp cutting of the Egyptian hieroglyphics, and suppose that instruments of any softer material can have been used. The cuttings may have been sharpened up with emery, which was within their reach in the islands of the Archipelago.

That the Egyptians were skilful engineers, as well as architects, we have abundant proof. The dykes directing the arbitrary overflow of the Nile, served also as raised roads—the only mode of land communication during the inundation: they followed a tortuous path, visiting the various towns and villages on their way. A canal was cut from the Nile to the Gulf of Suez, in the time of Rameses the Great; at the mouth of this canal were sluices to regulate the supply of water. And as early as the reign of Thothmosis III., between 1300 and 1400 B.C., the Lake Mœris was formed, which regulated the overflow of the Nile in that part of the country, and by its means thousands of acres were irrigated, and thus brought into cultivation.

I must now conclude this sketch of the Architecture of the Egyptians: space and time will not allow of more, or volumes might be written on the subject. If I have said enough to show how high a place the Egyptians occupied among ancient nations, and to how great an extent civilisation had been carried at that remote period, I must remain satisfied—referring the student for further information respecting this interesting people, to the valuable works of Sir Gardiner Wilkinson, Professor Rosellini, MM. Denon, Champollion, and others.

LIST OF AUTHORITIES.

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Wilkinson's Thebes.
harpe's History of Egypt.
Rosellini, Monumenti d'Egitto.
Canina, Architettura Antica.
Laborde's Illustrations.
Roberts's Egypt.
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Miss Martineau's Egypt and the Holy Land.

*** The Panorama of the Nile at present exhibiting at the Egyptian Hall, Piccadilly, will afford the student in Egyptian architecture a very clear idea of the stupendous works of antiquity, and well repay a visit. Of course it is to be supposed the student avails himself of the Egyptian Gallery in the British Museum, and of the Soane Museum.

DESCRIPTION OF THE COFFERDAM AT THE GREAT GRIMSBY DOCKS.

Engineer: James M. Rendel, Esq.

(*With an Engraving, Plate* II.)

The position occupied by this cofferdam is one of very great exposure. It is open immediately in front and on the eastward to an estuary 7 miles in width, and on the north-west to the whole current of the Humber for a reach of 20 miles, with a 25 feet rise of tide against it on the outside, and an excavated depth of 11 feet below low water immediately behind it, as necessary for laying the foundations of the locks. Moreover, the Humber is frequently exposed to violent storms; and finally, this cofferdam, unlike most structures of its class, must depend entirely on its own strength and form of construction for the requisite stability, as there is nothing in its whole length of 1,500 feet from which to derive support of any kind. It is therefore the more satisfactory to record that the work was completely carried out without any necessity arising for altering a single feature of the design in the course of its execution.

The plan of the cofferdam is a compound curve formed of two circular arcs, with a straight return on the west side; and the versed sine of the curved portion is (200 feet, or) $\frac{1}{7}$th of the span nearly. The dam consists of a triple line of whole timber sheet-piling, of which the outside row is battered half an inch per foot; and the other two rows are upright. The sheeting was all driven between gauge or bay piles, placed 10 feet apart; and the three last-driven piles of each bay were accurately sawn to a taper, in opposite directions, so as to wedge the remaining piles of the bay closely together. The average length of the piles in the first row is 55 feet; and that of the other two 45 feet. They are all driven to enter a bed of hard clay; but the ground through which they pass before reaching this bed is of a weak and silty character. The width between the first two rows of piling is 7 feet; and that between the centre and back row is 6 feet. The puddle clay occupying these spaces was mixed with one-fourth of small broken chalk stone for the first 5 feet in height, and perfect consolidation was insured by tipping the puddle throughout, from earth wagons on the top of the dam; single barrow-loads, even from that height, being entirely forbidden. The front and back rows of piling are secured by five tiers of whole timber double-walings; but in the centre row, the three lowest tiers of waling have been replaced by bands of wrought-iron, 6 inches broad by 1 inch thick, which are keyed together in lengths of 12 feet, and form a continuous tie on either side of the piling from one extremity of the dam to the other. In this capacity alone they are very serviceable; but the principal object of the arrangement is to insure an uninterrupted surface over the face of the sheet-piling on both sides, in order that the puddle may at all times be closely packed against it without leaving any of those voids which are inseparable from the use of ordinary timber walings in such situations, and serve as channels for any water that may pass along the through-bolts.

Another precaution against the admission of the water was observed in the arrangement of the long bolts, which were all distributed in such a manner as to break joint, never entirely passing through the dam, but in every case terminating at the outer row of piling, being screwed up against the wrought-iron plating, between which and the face of the piles a washer of vulcanised india-rubber was introduced. The long bolts are $2\frac{1}{4}$ inches in diameter at the lowest tier of walings, diminishing upwards to $1\frac{3}{4}$ inches.

It is, however, in the method of giving interior support to the structure that the greatest constructive excellence and originality of design will be found to exist. In place of the rows of single piles driven at a distance from a dam to which struts and braces are usually carried back, here are introduced buttresses or counterforts, consisting of close-driven rows of whole timber sheet-piling, 18 feet in depth, which spring immediately from the back row of the main pile sheeting, and occur at intervals of 25 feet throughout the work. The counterforts are strengthened by tiers of walings, corresponding with those in the inner row of the dam, and connected with them by strong wrought-iron angle-plates or knees, as well as by horizontal diagonal struts of whole timber, abutting in cast-iron dove-tailed sockets. By this arrangement, those portions of the dam included between the counterforts derive the full benefit of the strength of the latter, so that the whole structure may be said to stand virtually on a base equal to 32 feet, or the width of the dam plus the depth of the counterfort.

It is almost impossible to overrate the success which has attended this form of construction, for nothing can be more satisfactory than the manner in which the cofferdam has resisted the daily pressure of the water for the fourteen months since its construction, as well as the violence of several severe storms to which it has been exposed during that period. In order, however, to test its stability with the greatest degree of accuracy, the following arrangement was adopted:—Opposite to every fourth counterfort, at some distance from it, was driven a single pile, supporting a horizontal arm or index, fixed at the level of high-water spring tides; and of which, the extremity, graduated to parts of an inch, rested against the counterfort without being attached to it, so that any motion of the latter might be observed and measured on the graduated scale. The result of these observations was such as to inspire perfect confidence in the stability of the work; for under the pressure of high-water spring tides, the deflection at that level does not exceed half-an-inch. So great is the resisting power of the dam, that even in severe storms the blows of the waves against it are scarcely to be felt.

November 26th, 1849. Adam Smith.

FRENCH EXPOSITION IN LONDON.

If there were any doubt before as to the public mind being decidedly in favour of exhibitions of arts and manufactures, there can be none now. Events of late have given abundant evidence of this determined inclination; and the French Exposition in George-street, Hanover-square, very well finishes the year 1849, and is a good step in the progress towards 1851.

We have very lately shown the reasons why a great exhibition there is of less urgeny than in France, and we will only remind our readers that in France, or in Prussia, the public being less mechanical, there is a greater attraction in such an exhibition; and manufacturers elsewhere being less advanced, it was the more needful they should be brought forward in such a way, and receive every encouragement from the government and the public. Even Portugal has her exhibition of arts and manufactures; and throughout Europe, every energy of the government is strained to foster the slightest branches of industry. In England, our very prosperity makes us heedless, perhaps neglectful; and the most glorious inventions are unrewarded by the government, and their authors left to the mercies of pirates and lawyers for the chance of a subsistence from their labours. With the riches of manufacturing genius displayed in our great streets, there was no more call on our government to set up an exhibition, than to form a national workshop for supplying the population with wooden shoes.

For the want of such an institution some excuse may be pleaded; but there can be none that Watt, Trevithick, Wedgewood, Cartwright, and Stephenson, went down to the grave without sharing in the honours at the disposal of the executive. With a public triumph awarded to industry in 1851, an occasion may perhaps be taken to consider the claims of inventors. Some share in public honours and rewards may perhaps be given to them; some relief from the heavy patent-tax be awarded; some more rational tribunal than one composed of lawyers be instituted for their protection; and some facility be granted for the operations of capital in their behalf. Statues for the dead a grateful posterity may bestow; but bread for the living is not too much to ask of the present generation.

The institution of a National Exhibition of Arts and Manufactures by the French in the time of the great revolution, is sufficiently known; but it is not so easy to trace the progress of like institutions among ourselves. The establishment of the Society of Arts, above a hundred years ago, led to systematic, though restricted, exertions for the development of industry in this country; but their encouragement of inventions and discoveries, no less than their museum of models, was on too small a scale to effect any great good, and in later times it was very partial in its operation. Although separate exhibitions of individual inventions had been from time to time set up in London, we believe the first practical attempt to organise an exhibition of the industrial arts was about the year 1832, by Mr. Charles Payne. This exhibition was held in the old King's Mews, before that building was pulled down to make way for the National Gallery. After a very limited existence, the exhibition resulted in the establishment, by Mr. Charles Payne, of the Royal Adelaide Gallery for the Advancement of Science; and afterwards, of the Polytechnic Institution, which was organised on a still larger scale, and has been more successful in its operation.

Elsewhere, one who had rendered such considerable service to the public would not have been forgotten in the disposal of patronage; and Mr. Payne is, besides, the author of useful inventions for preserving meat and preparing timber, with which it is almost needless to say he has been left to struggle on without a help from public departments, and with all the discouragement incident in this country to those who prosecute useful undertakings. Certainly it was no mean service to establish a museum of economical productions, with working models of new machines, a course of lectures on mechanical inventions, and a laboratory and school of chemistry. The Polytechnic Institution, we have no hesitation in saying, has had a large share in bringing about the present favourable state of public feeling, and in the establishment of many valuable institutions.

The movement for free museums, twelve years ago, led to better arrangements at Woolwich and the other dockyards, as museums of the mechanical arts. The establishment, at the same time, of schools of design throughout the country, was a successful measure for the promotion of decorated manufactures. These schools have likewise held their yearly exhibitions of drawings and designs.

When the Royal Botanic Gardens were formed in the Regent's Park, a museum and exhibitions of economic botany were proposed; but little more has been done than to give the impulse to the government gardens at Kew, where a good beginning has been made of a museum. The Museum of Economic Geology is more advanced, but there is still an opening for a Museum of Economic Zoology. The Botanical and Zoological Gardens are open freely to students of the Royal Academy and Schools of Design; but whoever looks at our designs and compares them with those of the French as shown in Paris, or in London, will see how much we are behind in the study of natural history to what the French are. Indeed, the main strength of their designs is in their intimate acquaintance with nature; whereas, our students are still copying from drawings or casts from the antique.

The operations of the Mechanical Section of the British Association, and of the exhibitions and model yards of the Royal Agricultural Association, have resulted in yearly exhibitions, on a limited scale, of economical productions, which have made known the resources of many localities. The branch agricultural associations have extended the influence of such exhibitions.

The exhibitions by the Society of Arts, in the last few years, of objects of ornamental manufacture, should not be left out of sight in this enumeration.

Provincial exhibitions, as that at Birmingham and those for the benefit of mechanics' institutions have, some of them, been on a considerable scale.

Thus, besides the influence of the press, in urging the example of France, Flanders, Dutchland, and the Mechanics' Fairs of the United States, the public mind has been gradually prepared for a great national exhibition, and all the elements of it have been slowly organised. One reason for which we have given this sketch is to show that, so far from the exhibition of 1851 being a rash or doubtful venture, it has every element of success, and that nothing is wanted but a careful and honest administration. It is new, as a whole, but not in its parts; it has been rehearsed piecemeal, and is ready for the stage. The first Paris Exposition, restricted as was its organisation, was an experiment much more difficult, and much more doubtful.

In all our colonies, exhibitions similar to those already described exert a like influence, and are equally promotive of effective arrangements.

If, therefore, we look at the machinery we have now in operation, we may feel confident that all will work well; and we have in our local institutions, and in the familiarity of every district with these exhibitions, the means of surpassing any foreign effort. If any one comes to consider the number of our Societies, and the large sums yearly disbursed by them, he will feel little doubt of our resources.

Agricultural institutions descend from national associations to county and district societies; from these to agricultural clubs and cattle clubs.

Horticultural and floral exhibitions are held in every town. In London alone, 3,000*l.* are yearly given in prizes.

The migratory sections of the British Association, the scientific conversaziones, the Polytechnic associations, and the local exhibitions, afford yearly displays of mechanical inventions.

The exhibitions of the Society of Arts, and those of the Schools of Design, are rallying points for the designers.

In 1851, these are to be brought together, and nothing but gross mismanagement can afford a chance for failure. At any rate, we have invited the world to a competition in this its metropolis; we have thrown down the gauntlet, and we must not be beaten on our own ground and at our own weapons.

The French Exposition is a kind of advanced guard of our rivals, by which we may in some degree take measure of their strength. Within the walls of exhibition rooms—though those in George-street, Hanover-square, are large—it is not easy to give a complete illustration of the great Paris Exposition; nevertheless, the French Exposition constitutes in itself a fine exhibition, and affords no mean idea of the resources of our 'yond-Channel neighbours. Brought together on the suggestion and by the exertions of M. Sallandrouze de Lamornaix, it necessarily partakes much of the character of a private undertaking, and to some extent of a private speculation.

Monsieur Sallandrouze holds a high position in connection with the industrial interests of France, being the director of the great national manufacture of tapestry, and a member of the General Council of Manufactures, formerly a deputy, and in 1839, 1844, and 1849, one of the central jury or commission for the National Exposition. Many of the exhibitors held back from sending their productions, from doubts of the results of the Exposition, from jealousy of the proposer, or of the English; and many of those who sent did so from motives of speculation, in the hopes of making a sale of their goods. It is, therefore, as much a bazaar as an exhibition: but in either case M. Sallandrouze has achieved no mean success.

Machinery and the heavier productions have a very small share in the collection; neither have the coarser but more important manufactures more than a nominal representation, so that there is little to gratify technical interest; but it is as a demonstration of Parisian artistic skill, as a display of objects of luxury, that this Exposition remains as yet without an equal in England. This is the better for us: for our cottons and our iron we do not fear; but it is in articles of taste that we are behindhand, and for which we have the struggle to make; therefore we again thank M. Sallandrouze for this Exposition. Taken altogether, the tapestry, the silks, the porcelain, the glass, the bronzes, the cabinet-work, the knick-knackery, present a gorgeous display of cultivated taste, which the English public will see with surprise.

These things are not, however, to be seen and wondered at, and never again thought of, but as sights which have been; they must be considered and canvassed, and some profit be drawn from the lesson,—for this Exposition is suggestive of many striking thoughts. Why is it that France, which is neither so wealthy a land, nor has so wealthy an aristocracy, is able to beat us in these attributes of wealth? Have we the power of struggling with her for the mastery, or have we not—and is it worth our while?

To our mind, there is nothing disheartening in these considerations, but every ground of encouragement. Our army, it must be remembered, has not yet been brought together on the field; and when we look at that of our rivals, and acknowledge we have not yet seen a force so imposing, we must not give up hope for ourselves, but institute, so far as we can, a comparison of the details, which admit of it. "Have we as good a staff—as good engineers, as good artillery, infantry, cavalry, and train?" If we can answer "Yes" in each case—or if we can answer that though such an arm is worse, another is better—then we have no need to fear the result; and this, it strikes us, is what ought to be done here—to examine each branch, and then to review the whole. If this be done, those of our readers who know the resources of the country, will feel more confidence for 1851.

Tapestry we give up, for it is a government fancy in France, a "specialty," as are the great productions of Sèvres; and France must have the glory of these, as Rome of mosaics, Russia of grenadiers, and England of first-rates.

As to the porcelain and glass, putting the Sèvres demonstrations aside, we do not consider we are at all inferior to the French. In looking carefully at the invention, shape, colour, details, and finish, there is not that perfection on the part of the French which should reduce us to despair; but on the contrary, some very strong reasons for measuring weapons with them. There is to our seeming a purer taste in shape in England, and a richer taste in colour. We do not believe that in any branch of the arts, high or low, the French are our masters on these two heads. The French government have spent enormous sums at Sèvres, but our outward trade in earthenware is a much better stimulant. In porcelain, and in glass, we can make as good masterpieces; while the state of those manufactures is with ourselves much more healthy than in France, or any other country.

Our weavers can produce those specimens of silk which are the boast of the Lyons looms, but we are inferior in design in the general trade, because we have not reached the same height of cultivation. Spitalfields and Manchester will make a show in 1851; but this is not the test of a healthy condition. Our manufacturers, pattern drawers, weavers, buyers (as the *Art-Journal* well shows), mercers, and public, are not so well trained as in France. We want more and better schools of design, more picture galleries, and above all, more public botanic gardens. A free botanic garden in Victoria Park, and another at Manchester, will do more for Spitalfields and Manchester than almost any measure which can be proposed. Under decent management, these two botanic gardens could be established and upheld at a very moderate expense.

In the case of the Victoria Park, the twenty acres of land, which is the chief outlay, is already provided. Say, for laying-out paths 1,000*l.* If no show conservatory is tried, 5,000*l.* will make a good provision of hothouses and greenhouses. A curator can be had for 200*l.* a-year and a house. Gardeners are very cheap even in London—fourteen shillings each a-week for twelve men, will provide a sufficient establishment; for this 450*l.*; for materials, plants, coals, and other stock, 350*l.* a-year. Say 8,000*l.* for establishing the garden, greenhouses, and dwellings, and 1,000*l.* a-year for keeping it up. The 8,000*l.* might be got by public subscription; and the 1,000*l.* be raised by a rate or additional ground rent on the houses benefitted by Victoria Park.

Something of this kind must be done, for the establishments of London as now organised are inefficient. Kew is too far off; Chelsea, although admission is freely granted, is small, and a physic garden; Kensington and St. James's Park present little more than an arboretum. The Horticultural Gardens at Chiswick are too far off. The Royal Botanic Gardens in the Regent's Park are only accessible to artists, and not to the public. The Zoological Gardens are more acccessible, but even sixpence is too much for poor weavers. The gardens of the Messrs. Loddige, and other nurserymen, cannot be looked upon as available to the public. The Ornithological Collection in St. James's Park is very limited in its use; and the Surrey Zoological Gardens is a pay place.

Putting Kew out of the question, the only places open even for artists are the Royal Botanic and Zoological Gardens; and more students of the Royal Academy than of the School of Design go to either—indeed, very few from the School of Design. It is true plants are used at the Schools of Design; but free study from the growing plant is what is most wanted. For the instruction of the public at large, the means are quite inadequate; and besides the Victoria Park, we would ask for botanic gardens at Battersea and Greenwich.

The bronzes at the French Exposition are well executed; and this branch of art, which includes clock-cases and gilt plate, is carried on far beyond us. One reason is, that silver plate here takes the place which in France is held by gilt bronze. The latter can hardly be said to have an existence with us; not because we have not the means of execution, but because the fashion and the material are different. The works of Eck and Durand, Marchand, Deniere, Matifere, Susse, and Villemsens, will be looked upon with admiration.

The specimens of cabinet-work are most remarkable for the inlaying. Grohé, Marcelin, and Marchal, have some excellent work. In design, carving, and finish, we think we can meet the French; but we have not yet reached them as to price. We would particularly direct the attention of our readers to some of the inlaying, and the prices charged for it.

For gilding, we are inclined to give the palm to the English; but they beat us in silks for upholstery. It is, however, rather in the general design for decoration that they are our masters, than in separate articles of furniture.

There is one great specimen of paper-staining—a landscape by Zuber; and there is the Ascension, by Delicourt; but otherwise there is no great show in this way. We know, nevertheless, that the French beat us, and nothing can give us a fair chance for paper-hangings but more schools of design and botanic gardens, the removal of the excise on paper, and the abolition of the window duties; perhaps we ought to say the establishment of Mr. Cochrane's street orderlies, and street cleansing. Wanting light, and with horse-dung blown into our rooms and dignified with the name of dust, there is little inducement to set up those panoramas and other pictures, which are as entertaining as they are tasteful. Our manufacturers are starved out by an oppressive and neglectful government.

Of gold and silver plate there is little; and we are fully prepared to meet the French or any other manufacturers. Candelebra, epergnes, racing-cups, and other presentation plate, being the English fashion, where the French give Sèvres porcelain, Aubusson tapestry, or gilt vermeil. There are two objects that require a special consideration—swords presented to the Presidents of two Spanish-American republics. This, and a plan of the city of Mejico (Mexico), by Bauerkeller, put us in mind what a revenue the French manufacturers derive from Spanish-America. In Mexico, and throughout the South, there are swarms of French shopkeepers and pedlars; and the similarity of language favours a knowledge of Spanish tastes and propensities. This is quite neglected here; and, so far as we are aware, there is no public teacher of the Spanish language and learning in Liverpool, Manchester, Birmingham, Sheffield, or Glasgow, and the professors in the two London colleges have few scholars. A little attention to Spanish in our great seats of trade and manufactures, would give us a chance with fifty millions of Spaniards.

In jewellery of all kinds there is a very fair show, and we may name Daniel, Rouvenat, and Froment-Meurice; but there is nothing to frighten London and Birmingham, although the Parisians are great masters in these arts. There are some good works in gold, silver, steel, mother-of-pearl, tortoiseshell, and other materials.

Some of the shawls by Deneirouze, Gaussen and Pouzadoux, and Rosset and Normand, are very good, and will well repay examination.

The patterns and designs for silk, cotton, and tapestry are what will be looked at narrowly, for here is a stronghold of the French; and they have no unworthy representatives in Couder, Claude, Braun, Lubiensky, and others. Couder has designs of many classes, in each of which the style most suitable to the material is adopted. Here, as we have before hinted, the study of flowers and of natural history is very apparent, and the necessity for this was fully pointed out twelve years ago by the Committee on Schools of Design. If we are to beat the French, it must be with their own weapons: and in despite of the pig-headedness of our manufacturers, and the self-interested prejudice of academicians, the instruction in our schools of design must be of the highest class, and must be based on the study of nature, from the human figure down to the slightly-organised flower.

M. Mathias has specimens of the scientific works he has published, and of collections of technical works for public libraries. The exertions of M. Mathias should instruct us, for if public industrial libraries are necessary in France, so are they here. We may remind our readers that they have now an opportunity of purchasing works in those branches of science in which the French are proficient.

The zinc exhibition of the Vielle Montagne Company gives a very good illustration of the varied uses to which that metal is now being applied; and although zinc is much worked up here, still Flanders is the chief seat of production and supply, and this collection cannot fail to prove useful to many of our architects and engineers. The zinc mouldings and ship-sheathing are not among the least promising applications,

We shall now say a few words upon several subjects for which we have little space at our disposal. The painted glass is good; but we can equal it. There is some good carpeting; but there again we can come in. M. Le Molt has a simple galvanic battery and some philosophical apparatus. The lace shown by M. Guyot de Lisle is a worthy production of French skill. Some of the tapestries shown by M. Sallandrouze are wonderful—the brilliancy of oil-painting is approached; there wants only a varnish to complete the identity. The leather ornaments, by Dulud, are good, and almost equal in effect to the Cannabic composition. The children's toys of M. Theronde should not pass unnoticed. The toy business employs a thousand people in London, and yet we import largely from the High Dutch. Carved ivory flourishes at Dieppe, and constitutes the staple of that town. The fancy stationery is very well represented, and is a branch of industry in which we are making progress, though the paper duty is heavily against us. M. Gruel has some bookbinding of a highly artistic character. M. Charpentier has some good chandeliers and lamps. There is an interesting specimen of wood mosaic, a figure of a monk.

Undoubtedly there is not that wealth in France there is here, neither are there so many wealthy men, but France has many compensations. There are better means of instruction, and the public are more tastefully trained: the government acts as grand patron. The church still creates a great demand for painting, carving, stained glass, vestments, tapestries, jewellery, and church furniture, even to artificial flowers. The great stay, however, is this, that Paris has created and enjoys a reputation for taste, which commands the orders of kings, nobles, and churches throughout the old world and the new. Paris has the market of the world—we, not even that of our own empire, for the French share, too, in this. The fight is for millions, and we have a good chance if we will but try—we are making good way; where we try we succeed, and we must go on. Those who deal with us for cotton and iron will deal with us for silks, paper-hangings, and cabinet-work; the market is as open to us as to the French; indeed, we have more commercial facilities, but we want instruction, and this is the direction in which exertion must be made. The exhibition of 1851 will only be worth anything as a means of public instruction; and therefore is it the more desirable all our rivals should be invited; but the whole organisation of industrial instruction must be strengthened. Drawing in the national schools, schools of design, with the live model, free industrial libraries, schools of chemistry and mechanics, botanic gardens, picture-galleries, art unions, freedom from excises and the tax on God's light; these are what we want to achieve success. The demand seems large, but the cost is small.

REGISTER OF NEW PATENTS.

STONEWARE PIPES.

BENNETT ALFRED BURTON, of John's-place, Holland-street, Southwark, London, for "*certain improvements in the manufacture of pipes, tiles, bricks, stairs, copings, and other like or similar articles, from plastic materials; also improvements in machinery to be employed therein.*"—Granted June 7; Enrolled December 6, 1849.

The object of this invention is to produce pipes and other articles from plastic materials of greater strength and durability, more regular in their structure, and of better finish, than has ever yet been accomplished. The manner in which the inventor effects this object is by compressing the plastic material of which pipes and other articles are composed, by a process of rolling; which is found not only to increase the strength of such articles as may be subjected to such process, but also to give them a smoother surface, so that they may be less liable to the accumulation of deposit; and in the case of pipes, will be found to offer less resistance to the passage of fluids.

The machine for making pipes according to this invention consists of a vertical framework, supporting two clay cylinders, so arranged that they can be brought alternately below the screw and piston, for the purpose of forcing the clay through the dies. The object of such an arrangement is to allow of one cylinder being filled during the process of forcing through the die the clay contained in the other cylinder.

To the centre part of the die (see fig. 1) there is attached a mandril *a*, the lower end of which just comes below the centre line of four rollers, turned and arranged as shown at fig. 2, which represents a plan of the rollers, and their bearings supported by a cast-iron frame *b*, *b*. The mode of driving the rollers is by a wheel *c*, keyed upon the end of the shaft *d*, of the fixed roller, and three pairs of bevel-wheels *e*, *e*, *e*. The wheel *c*, is driven by a pinion, keyed upon the end of the main driving-shaft of the machine, which shaft also gives motion, by means of an upright shaft and suitable gearing, to the screw, which forces the clay contained in the cylinder through the die. It will be seen on referring to the plan that the rollers will be drawn in one and the same direction, and with the same surface velocity.

The process of manufacturing pipes according to this invention is therefore as follows:—The clay, as it is forced through the die in the form of a pipe, slips over the mandril *a*. The length of pipe required is then cut off, and afterwards drawn by the motion of the rollers over the end of the mandril, whereby the particles of matter forming the pipe become compressed or consolidated to such an extent, that when baked in the usual way they have been found, by repeated experiments, to be upwards of 75 per cent. stronger than pipes made from the same clay, but manufactured in the ordinary way; besides being more regular in their structure, and in every respect better finished.

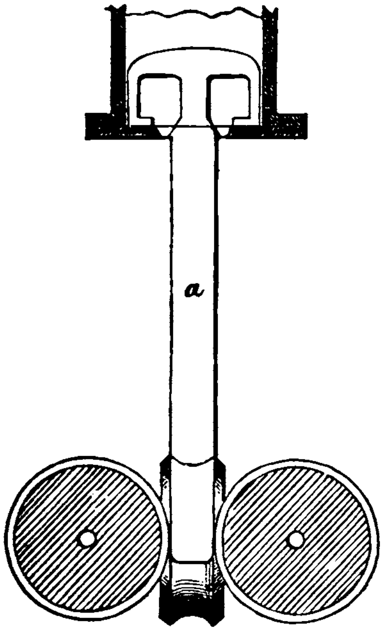


Fig. 1.

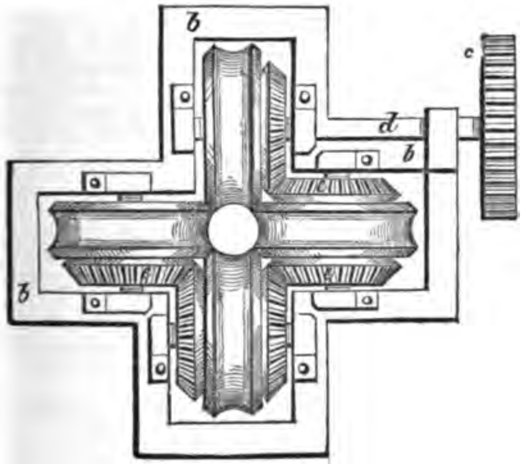


Fig. 2.

It will be seen from the above that the pipes are compressed immediately after passing through the die. This will, however, depend upon the nature and consistency of the clay, and state of the weather; for in some cases it may perhaps be desirable to let them stand in a dry place for two or three days previous to being rolled, which will entirely depend upon circumstances, and must be left in some measure to the judgment of the workmen: It will also be seen, with regard to pipes of small diameter, that the rolling machine would do a greater amount of work than a pipe machine having but one die. Pipes may therefore be made in a separate machine, having any required number of dies, and afterwards rolled. For this purpose, the specification describes a modification of the above machine, to be used for the purpose of compressing only.

In cases where the pipe is required to have a taper hole, the inventor employs a mandril made taper at the point, the mandril being gradually withdrawn by a screw or other suitable means, during the time the pipe is passing between the rollers.

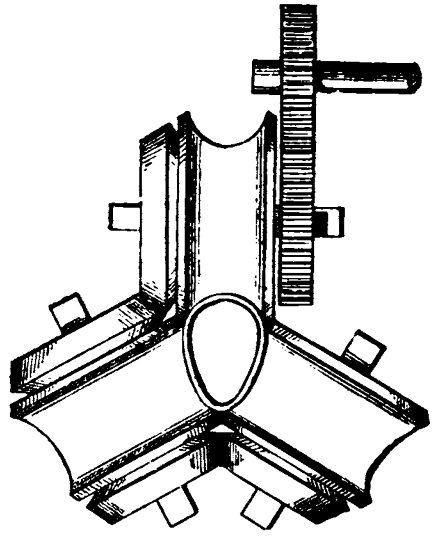


Fig. 3.

When the article to be compressed is not of a circular form, two, three, or more rollers may be employed, as the nature of the case may require (see fig. 3); which shows the form, mode of arranging and driving three rollers for compressing an oval pipe.

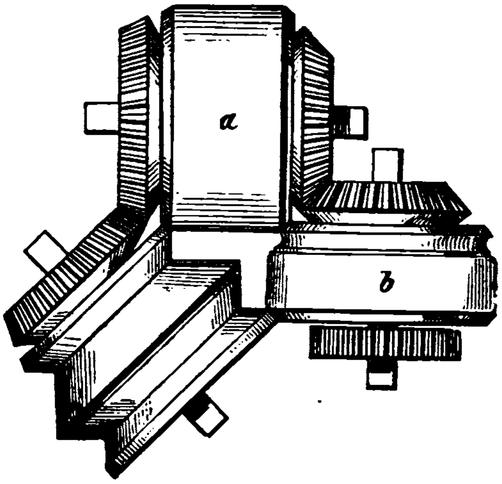


Fig. 4.

Fig. 4 shows the form, mode of arranging and driving three rollers for compressing a stairs' tread or step; the rollers *a*, and *b*, may, in this case, be engraved with any suitable device, or pattern, which will be impressed on the top side and front of the step, as shown at fig. 5, which represents an isometrical view of a step manufactured according to this invention.

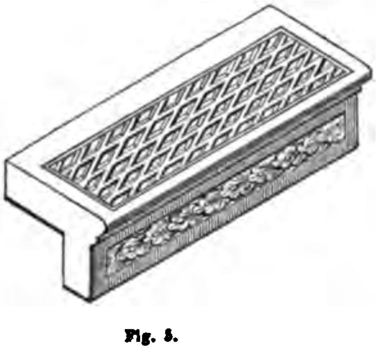


Fig. 5.

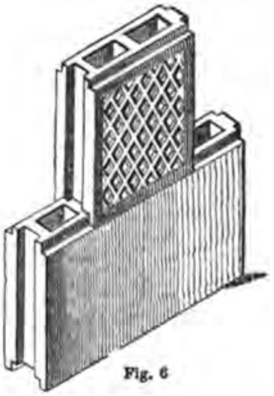


Fig. 6

Fig. 6, is an isometrical view of three hollow bricks, and the manner in which they fit together. Hollow bricks or tiles, of the form shown in the drawing, are made by forcing clay through a die of suitable form, and afterwards compressing the clay, by passing it between four rollers, two of which are turned of such a form as to produce a rebate on the edges of the bricks; the other two being engraved on their peripheries, so as to produce on the sides of the brick or tile, any suitable device or pattern. The ends of the brick are rebated afterwards, in a separate machine.

Fig. 7.

The specification having described the mode of arranging rollers for compressing hollow bricks, copings, columns, and articles to be employed for building purposes, further states, that by the application of cams, eccentrics, or convolute rollers, articles of a variety of forms, so far as regards their length and tranverse section, may be produced by the process of rolling, as hereinbefore described.

Another part of these improvements relates to the mode of making bends for pipes; and consists in so constructing the die that a bend of any required curve can be produced, simply by forcing the clay or other plastic material through the die; whereby the moulds employed in the process of making bends as heretofore are dispensed with. Bend pipes, after they have been made as described in the specification, are afterwards compressed by passing them between rollers as described.

The specification, after describing several machines for cutting socket, or rebate and screw joints upon the ends of earthenware pipes, concludes somewhat as follows:—I would have it understood, that I do not claim as my invention the combination of four rollers, and mode of driving, as represented at fig. 2, the same having already been applied to the manufacture of iron pipes. But that which I do claim as my invention is—

First, the application of rollers turned of such a form, and arranged in such a manner, that they may be employed for compressing or consolidating the particles of matter composing pipes, tiles, bricks, copings, stairs' treads, pillars, columns, or other articles composed of plastic materials, intended for building, drainage, and other purposes.

Secondly, I claim the general arrangement and combination of parts composing the machines for making and compressing pipes, as hereinbefore described.

Thirdly, the mode of making bends for pipes, as described.

Lastly, the general arrangement and combination of parts composing the machines for forming rebate, or socket and screw-joints.

Experiments on Stoneware Pipes.

Experiments *showing the relative strength of Pipes made in the ordinary manner, and by* A. and M. Burton's *Patent Machine.—"Unrolled" being the common pipe, and "Rolled" indicating that the pipe has passed through the Patent Machine.*

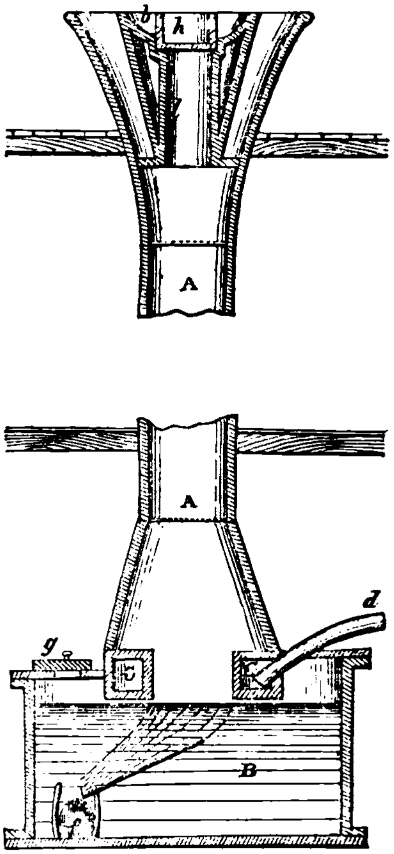
No. of Experiment.	Bore of Pipe in inches.	Thickness of Pipe in inches.	Length of Pipe in inches.	Weight of Pipe in lbs.	Breaking weight in lbs. pressure per inch.	Remarks.
1	2·812	·469	20·68	8 75	420	Rolled Fine Clay
2	2·87	·471	22·37	9·25	380	" "
3	2·87	·471	22·37	9·25	280	" "
4	2·68	·472	21·	7·75	180	Unrolled Fine Clay
5	2·7	·473	21·5	7·89	170	" "
6	2·69	·471	21·3	7·9	200	" "
7	2·75	·468	21·5	8·12	140	Rolled Coarse Clay
8	2 75	·468	22 31	8 25	270	" "
9	2·75	·468	22·37	8·25	260	" "
10	2 75	·5	21·87	8 25	160	Unrolled Coarse Clay
11	2 75	·468	21·37	8·5	120	" "
12	2·73	·475	21·47	8·36	110	" "
13	2 375	·656	23·12	12·25	660	Rolled Fine Clay
14	2 375	·636	22 75	12·25	860	" "
15	2·375	·630	24·12	12 75	500	" "

SHOT.

David Smith, of New York, United States of America, lead manufacturer, for "*certain new and useful improvements in the means of manufacturing certain articles in lead.*"—Granted May 29; Enrolled November 29, 1849.

The improvements relate to the manufacturing of "drop-shot," which are now formed by allowing molten lead to fall from a great height, the metal at the same time being separated by the pouring-pan into particles, according to the size of the shot to be manufactured. The falling of the lead through the atmosphere causes the particles to assume a globular form; and in order that such may be properly effected, it is necessary that the height of the fall shall be such, that the falling lead will acquire a certain velocity through the atmosphere; hence the necessity of erecting high towers for the purpose, which entails great outlay in the manufacture of shot.

To obviate this, the inventor proposes employing a height of about 50 feet, and yet at the same time obtaining an effect equal to a fall of 150 feet, or more if desired; and which is obtained by driving a current of air in a contrary direction, the effect of which, combined with the velocity of the falling lead, is equivalent to the ordinary heights employed. The annexed engraving is a section of the apparatus, for the purpose of carrying out this invention. A, is a vertical metal tube, about twenty inches in diameter, the lower end is enlarged in the form of a truncated cone, and rests on a chamber B, containing water, which forms as it were a base or pedestal for the whole. In the upper part of this vessel B, is an annular compartment C, the inner diameter of which is equal to the diameter of the tube A, and the outer diameter equal to the large end of the cone. The upper surface of this annular chamber is thickly perforated with holes, by which air is admitted to the body of the pipe; the air being forced into the annular chamber C, through the pipe *d*, from any blowing apparatus calculated to produce a sufficiency of blast to give the required velocity in the tube A. *e*, is a shoot to guide the shot into the vessel *f*, and which may be removed through the closed aperture *g*, when filled. The water rising up in the shoot *e*, receives the falling shot, while the inclosed water case prevents any escape of air from below. The current of air first entering the annular space C, becomes thoroughly diffused over the entire area of the pipe, by transmission through the numerous apertures. The upper part of the tube A, is surmounted by a trumpet-mouthed extension, the larger annular space affording ready egress for the air forced in at the bottom, while the centre is occupied by the pouring-pot *h*, which rests over a concentric cylindrical channel *i*, supported from a six-armed frame, secured in the tube at *k*. The pouring pot, as usual, is perforated at bottom, so as to separate and diffuse the lead over the area of the channel *i*; the pouring pot *h*, rests in, and is surrounded by a spill chamber *l*, to receive any lead that may run over, and intercept its descent through the tube.



The metal thus falling through a space of 50 feet, must have an upward current of air that will render it equal to the velocity attained in falling 150 feet. By increasing the current of air, an equivalent for any height of fall may be obtained. Instead of blowing in air at the bottom, the same result may be obtained by exhaustion from the top or funnel mouth, the outer space of which must be inclosed and connected with some suitable exhaust apparatus, and in which case the annular chest at the bottom will be dispensed with, and free vent given for the ingress of air.

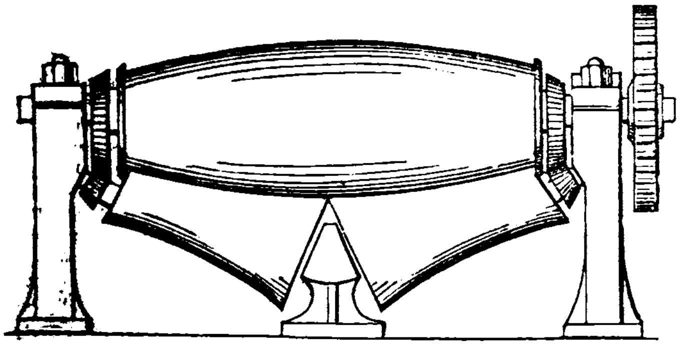
IRON CASKS OR VESSELS.

Solomon Israel Da Costa, of Great St. Helens, city of London, civil engineer, for "*improvements in vessels for holding solids or fluids, and in machinery for manufacturing such vessels.*"—Granted May 22; Enrolled November 21, 1849. [Reported in the *Patent Journal.*]

This invention relates—first, to an improved mode of constructing barrel-shaped vessels of iron, and also to machinery used in the construction of such vessels.

In the manufacture of these vessels the patentee forms the body part by bending the plate or sheet iron by means of rollers, somewhat similar to plate-bending rollers used for boiler purposes; the plate used being either such as will form either one-half of the vessel, or complete the entire circle. The upper bending or shaping roller, for this purpose, is formed of a barrel-shape (that is, larger at the centre than at the ends), more or less, according to the shape to be given to the plate, while the under roller is the reverse of the upper, so as to receive it and squeeze the plate between them. On the ends of the upper roller are two cutting discs, or edges, which pare the edges of the plate as it is passed between the rollers. A third roller is employed to guide and give the direction to the plate under operation, its proximity to and position with regard to the other rollers being adjustable for the purpose of bending the plate, more or less, according to the size of the vessel to be made, as well understood in the bending of boiler plates. The plate, after being heated red hot, is passed through the rollers, which, at one and the same operation, bend, shape, and trim the body part of the vessel.

The plate, after being bent, encircles the upper roller; and in order to remove it readily, the patentee forms one of the bearings of a spherical shape, which allows the opposite end to be raised, for the purpose of removing the bent plate. The rollers are so formed as to set back a small portion of the plate at each end, so as to form an enlargement for the reception of the ends of the cask; the enlarged end is of a cylindrical form, or rather slightly coned outwards, to render the ends more easily introduced and fitted. The ends are formed of plate-iron, having an edge turned up, which fits the enlarged part of the end, and is, after being fitted, brazed in its place; these casks are furnished with thickness rings at the bung and tap holes, such bungs being rivetted, or otherwise secured, in their position.



The annexed engraving represents in elevation a set of rollers of a different construction; instead of one lower roller being employed, two are substituted, the third or bending roller being the same as before described, but which is not shown in the engraving; these three rollers are geared together in such manner as to produce a like motion of their peripheries, or, as near as possible, taking the medium of their diameter. The cutters are here represented at either end of the upper roller, but the portion which is set back to form the enlargement of the end is omitted. The superfluous metal is cut off by the cutters passing or crossing the ends of the upper rollers. The action of these rollers will be sufficiently understood without further description. A third machine for this purpose consists of two blocks, having semicircular cavities, opposed to each other, and which are drawn together or expanded by means of right and left hand screws, on a shaft; the plate having been partially bent, is introduced between the two blocks, and by drawing them together, completes nearly the entire circle. The hollows or cavities of these blocks are of the same barrel form, and in order to press the bent plate into which, the patentee employs a shaft, concentric with the hollow blocks, carrying between two crank-arms and a barrel-shaped roller; after the plate has been partially formed, the shaft is caused to rotate, by which the roller will be pressed and rolled round the interior surface of the vessel under formation, causing it to be compressed into the form or cavity in the blocks. The plate, while under operation, is made red hot as before.

The second part has reference to the manufacture of such articles as are usually struck or stamped in metal, for which purpose the patentee employs a press very similar to the ordinary screw-press, with dies—that is, male and female of the ordinary kind. But instead of using sheets or plates of metal, the patentee uses the metal in a molten or semi-molten state, which is deposited in the bottom of the female die, in sufficient quantity to produce the article required. The upper die is then brought down while the metal is still soft or in a molten state, by which it is caused to rise up and fill the space between the dies; a second depression of the upper die further imparting the impression to be imparted to the article. Where the impression is required to be sharper than can be obtained by this means, such articles may be again struck in the ordinary manner, by which much finer and sharper lines may be obtained, and with much less work than heretofore.

The third part refers to the manufacture of hollow-formed vessels in clay, cement, or other plastic material, which is somewhat similar to the foregoing mode of stamping metals, the object being to prevent the formation of bubbles or honeycomb in the articles so manufactured. The clay or other plastic material is placed in the bottom of the hollow mould, which, as in the last case, rises when the plunger or die is depressed, so as to fill the space for its reception, and give the required form to the article to be produced, and by which all bubbles or imperfections resulting from the confinement of air in the moulds are avoided.

The patentee claims: First—The improved vessel or cask, manufactured in the manner described; and also the machinery or apparatus for making the same.

Secondly—The mode of pressing up in moulds or dies, vessels or hollow forms, made in molten or semi-molten metal of any kind suitable for the purpose, so as to produce wholly or in part the shape required, and which shape may be again struck in another die or dies in the ordinary manner of striking up hollow metal goods, by which means a still sharper outline or finer impression may be obtained.

Thirdly—The method of making vessels or shapes of hollow forms in clay, cement, or other plastic material suitable for such hollow forms, and pressed upwards from below, which will prevent in a great measure the formation of air bubbles, such bubbles producing the vessel of a honeycomb and defective character; which mode of manufacture does not require the centre disc die, which in certain articles is necessary, and is usually placed at the bottom, and held by one or more cross-pieces, which separate the plastic form as it passes through, as for instance, in clay pipes.

ELASTICITY OF VAPOURS.

Sir—In reprinting, in your *Journal* for December, the principal portions of my paper on the Elasticity of Vapours (originally published in the *Edinburgh New Philosophical Journal* for July), I observe that the co-efficients of the formula for calculating the elasticity of the vapour of mercury have been omitted.

As that formula is of considerable utility in delicate observations of the elasticity of other vapours, I annex the co-efficients, in case you may wish to publish them.

The formula being $\text{Log } P = \alpha - \frac{\beta}{t}$,

α for millimetres of mercury = 7·5305
„ for English inches of mercury = 6·1259
Log β for the centigrade scale = 3·4685511
„ for Fahrenheit's scale = 3·7238236

I am, &c.

Edinburgh, *Dec.* 10, 1849. W. J. Macquorn Rankine.

DISCHARGE OF WATER THROUGH DRAIN PIPES.

Experiments on the Discharge of Water from Pipes, made under the sanction of the Metropolitan Commissioners of Sewers.—[From the *Mechanics' Magazine.*]

I send, for the guidance or consideration of your readers, some account of experiments made on the discharge of water from pipes, with a view to ascertain the requisite sizes of various aqueducts for the purposes of drainage. It was necessary to conduct these experiments, as to arrangements of apparatus, in a different manner than if it had been required to know the necessary sizes of pipes for supplying the town with water, as, in the former case, there being no pressure arising from head, a flow of water of uniform section is maintained by the continual addition of lateral streams: and the length of the aqueduct, therefore, as an element of friction, may have little or no influence on the velocity of the main current; while in the case of waterworks, the velocity of the water depending on the head at the origin of the system, length of pipe is a most important element in calculation; and the friction arising from this condition is often the chief force to be overcome. In fact, under these two circumstances, reverse effects are produced: for in a drain, if the length be increased, and junctions be proportionally added, a greater amount of discharge will be the result (I always assume that the junctions are made in the most scientific manner with regard to their siding the main line); and in another respect the operations of a system of drainage and a system of waterworks are curiously dissimilar; for, in the former, the chief current being supplied immediately by its tributary mains, sustained by their various ramifications, and ultimately fed by a multitude of small mouths, the whole operation proceeds naturally and easily by the silent effort of gravitation; while in the latter case, the main line being first charged, the water has to be forced with sufficient power to divide itself, and move with great velocity in a multitude of different directions, up hill and down hill, through intricate and narrow passages, turning at every variety of angle. In the latter work, again, the power is generated at once at the head of the system, and is continually being expended so long as it acts; but in the former, force is self-generating—it accumulates as the operation enlarges, until the small tributaries become important streams, and these streams an impetuous torrent. It is easy to perceive at once what an important part *friction* plays in the one case to what it does in the other.

Hence, with regard to *formulæ* constructedon the basis of experiments made with heads of water at the ends of pipes, they have proved totally useless as means of ascertaining the proper sizes of drains and sewers; and when tested by the actual discharge of a drain, I have found them so much in error that I could have guessed by the eye much nearer the truth. The *formulæ* of Prony, Dubuat, Eytelwein, Genieys, Young, Smeaton, and others, not only each of them departs very wide of the truth when applied for the purposes of drainage, but they all disagree the one with the other, so much as to destroy confidence in any one of them, unless confirmed by other evidence. The experiments which I am about to describe were made under the sanction of the Metropolitan Commissioners of Sewers, on their premises in Greek-street.

The apparatus used was as follows:—A strong platform, 100 feet long, was erected, fixed to move about a central axis at one end, and free to be moved at the other by a chain and windlass, so as to afford a range from the horizontal plane to a declivity of 1 in 10. A tank, holding 1600 gallons, was placed at the upper end; and another tank of sufficient dimensions, received and measured the water discharged at the lower end. On this platform lines of pipes, varying from 3 inches to 12 inches diameter, were tried. The pipes consisted of the ordinary Vauxhall stoneware, in two-feet lengths; and a careful selection of them was made as to accuracy of bore and dimensions. They were laid in straight lines of uniform inclination, and the pipe joints were rendered water-tight with clay. On each side of a line of pipes, five junctions were attached at intervals, by which the water was admitted, as well as at the head of the pipe. The entrance of the water was regulated by sluices; so that while the head of the pipe was just filled, water was at the same time admitted by the junctions sufficient to maintain the pipe full throughout its entire length. Under these circumstances, we found—to mention only one result—that a line of 6-inch pipes, 100 feet long, at an inclination of 1 in 60, discharged 75 cubic feet per minute. The same experiment, repeated with the line of pipes reduced to 50 feet in length, gave very nearly the same result. Without the addition of junctions, the transverse sectional area of the stream of water near the discharging end was reduced to one-fifth of the corresponding area of the pipe, and it required a simple head of water of about 22 inches to give the same result as that accruing under the circumstances of the junctions. With regard to varying sizes and inclinations, we found, sufficiently for practical purposes, that the squares of the discharges are as the fifth powers of the diameters; and again, that in steeper declivities than 1 in 70, the discharges are as the square roots of the inclinations; but at less declivities than 1 in 70, the ratios of the discharges diminish very rapidly, and are governed by no constant law. At a certain small declivity, the relative discharge is as the fifth root of the inclination; at a smaller declivity, it is found as seventh root of the inclination; and so on as it approaches the horizontal plane. This may be exemplified by the following results found by actual experiment:—

Discharges of a 6-inch Pipe at Several Inclinations.

Inclination.	Discharges in 100ft. per minute.	Inclination.	Discharges in 100ft. per minute.
1 in 60	75	1 in 320	49
1 in 80	68	1 in 400	48·5
1 in 100	63	1 in 480	48
1 in 120	59	1 in 640	47·5
1 in 160	54	1 in 800	47·2
1 in 200	52	1 in 1200	46·7
1 in 240	50	Level	46

The series of hydraulic experiments from which the foregoing is selected, has been in operation for the last two years, at an expense of upwards of 2000*l*. The experiments conducted at Greek-street were a continuation of similar experiments made in the Fleet sewer: in the latter place the sewage was used, and in the former pure water supplied by the New River Company.

The conclusion arrived at is, that the requisite sizes of drains and sewers can be determined (near enough for practical purposes, as an important circumstance has to be considered in providing for the deposition of solid matter, which disadvantageously alters the *form* of the aqueduct, and contracts the water-way) by taking the result of the 6-inch pipe under the circumstances before mentioned as a *datum*, and assuming that the squares of the discharges are as the fifth powers of the diameters.

That at greater declivities than 1 in 70 the discharges are as the square roots of the inclinations.

That at less declivities than 1 in 70 the usual law will not obtain; but near approximations to the truth may be obtained by observing the relative discharges of a pipe laid at various small inclinations.

That increasing the number of junctions at intervals accelerates the velocity of the main stream in a ratio which increases as the square root of the inclination, and which is greater than the ratio of resistance due to a proportionable increase in the length of the aqueduct. The velocities at which the lateral streams enter the main line, is a most important circumstance governing the flow of water. In practice, these velocities are constantly variable, considered individually, and always different considered collectively, so that their united effect it is difficult to estimate. Again; the same sewer at different periods may be quite filled, but discharge in a given time very different quantities of water. It should be mentioned that in the case of the 6-inch pipe, which discharged 75 cubic feet per minute, the lateral streams had a velocity of a few feet per second, and the junctions were placed at an angle of about 35° with the main line. It is needless to say that all junctions should be made as nearly parallel with the main line as possible, otherwise the forces of the lateral currents may impede, rather than maintain or accelerate the main streams.

The conclusion of the labours of the authors of the several formulæ before quoted, left the science of hydraulics in such a state that no man, except by his own practical observation, could tell what an aqueduct, under any given conditions, would discharge. This will be so apparent to any one who will take the trouble to examine and compare the various formulæ the one with the other, and to test their general pretensions by some known facts, that I need dwell on it no longer. It would be a valuable thing if practical men would make a common record of facts occurring in their own experience,—*facts, not conclusions derived.* No doubt the facts exist in sufficient abundance; but they are too scattered, or appropriated as secrets, so that the engineer is often obliged to assume results which he has not had an opportunity of verifying by practical experience. Had such a record been current, the formulæ of the hydraulicians could not have been received as orthodoxy by the scientific world.

1, *Greek-street, Soho,*
Dec. 4, 1849.

J. L. Hale,
Civil Engineer.

THE RUDIMENTARY TREATISES.

Rudimentary Dictionary of Terms used in Civil Architecture, Naval Architecture, Building and Construction, Early and Ecclesiastical Art, Civil Engineering, Mechanical Engineering, Fine Art, Mining, Surveying, &c. By John Weale, Author of 'Divers Works of Early Masters in Christian Decoration,' &c., &c. London: Weale, 1850.

The booksellers in Berlin have lately been subjected to a grievous oppression—the necessity of reading the books they publish or sell. Grocers, they say, never eat figs,—booksellers do not read books; and the Berlin booksellers have remonstrated against the tyranny of the police, which subjects them to the task of reading the contents of their own shelves. With the booksellers we take part, if only for this reason: that the police are throwing away their resources—disarming justice of her sharpest edged sword; for if the reading were only enforced at the proper time, and reserved as the punishment of offences instead of an engine of prevention, we believe the law would be armed with greater terrors. There are booksellers in London, no less than in Paris and Berlin, to whom we would not bate one page of the nauseous and nonsensical trash which they have been guilty of giving to the world; and the *lex talionis* dictates they should be duly punished by its perusal.

From reading to writing, there is, however, a step; and upon that booksellers but seldom venture, though there are some distinguished men in that business who have not hesitated. It is not necessary that every man among them should be put to the test; but it is gratifying to see they can take the pen in their hands, and that they have a practical knowledge how a book ought to be written. Mr. Weale, it is true, is not a new writer, but nevertheless there is no harm in making a commentary on his proceedings, for a man is likely to be none the worse judge of a book who can write one himself. For a man to be a good and enterprising publisher, he must have some knowledge of the requirements of the public, and the means of gratifying them; and just in proportion to his own knowledge and the interest he feels, will be the measure of his exertions. A kindred zeal for the welfare of the pursuit with which he is connected, will sometimes prompt him to produce works of a higher class than his temporary interests would appear to justify. He must be beyond his customers rather than merely up to their mark; he must lean to the authors rather than to the book-buyers; for if he only follow the taste of the public, the taste of the public is not likely to make a forward movement. A publisher may suit the taste of the public to a T, and yet only produce marrowbone-and-cleaver polkas; or he may humbug, shave, and softsawder the public in another line, and spend thousands in engraving royal marriages and christenings, and such miserable flunkeyism, when a like expenditure in the hands of a Boydell would give lasting glory to English art. Mr. Carter Hall has been the means of rendering essential service to the English school, by publishing in the *Art-Journal* the small engravings of the Vernon Gallery; while, if we turn from him, a literary man, to the print-publishers, we find that those who have the means, completely misuse them, and while making enormous profits bring the arts into contempt. The Art Union and the print publishers would be enough to swamp English art, if it depended on them alone.

We are, therefore, for the march of intellect and education; for having educated writers, educated artists, educated critics, educated publishers, and an educated public. An enlightened publisher will often be called upon to carry out an enterprise of considerable importance and considerable risk—nay, he may even suggest it; and we are sure bookselling has been none the worse for such men as Messrs. Charles Knight, Lovell Reeve, and John Weale. Charles Knight's love of Shakspeare has made a Shakspearian era, at a time when Shakspeare has been unshrined in his greatest temples, and left to the incense of his meanest priests. Mr. Knight has also taken a great share in those popular works under his name which have done so much for the spread of knowledge. Had he been less in love with his subject, he would have done less.

The Dictionary of Terms is a kind of introduction to the Rudimentary works—a series which we make no question will do very much good to the cause of education. It was, it seems, Colonel Reid, the author of the 'Law of Storms,' who gave the first hint for this series. At Bermuda, and afterwards at Barbadoes, he took a personal interest in the construction of several useful works; and he saw the lamentable want of knowledge of the West Indian workmen. For the commonest work, not only an engineer must be sent out, but workmen; and this is one of the great obstacles to West Indian progress. The introduction of Mr. Gordon's iron lighthouse, and of Messrs. H. O. and A. Robinson's sugar mills, which have boiler and rollers on the same platform, are therefore most useful in the islands; for what would here be simple machinery, cannot, out there, command the services of a good blacksmith. It is further to be observed, that the planters are not by any means fitly taught; for they go out from England raw lads, and learn little after: and it is not, therefore, to be looked for that they should teach negro carpenters and blacksmiths. As one means of instruction, Colonel Reid forwarded to Mr. Weale a copy of Professor Fownes's Rudimentary Chemistry, with a recommendation that it should be printed; and it was adopted as the first of the new series. We believe we are right in saying that not only in the West Indies, but likewise in the East, many of these Rudimentary works have been distributed by the government, for popular instruction.

Pinnock's Catechisms were good compilations in their day. They formed a popular cyclopædia, a curriculum of education, which, for completeness, has not yet been equalled; and in language, no less than in many branches of science, they have been the means of greatly promoting the love of knowledge. It was not that a ninepenny treatise was held forth as self-sufficient for the acquirement of any branch of knowledge, but it was a preparatory step—as an introduction, and as an incentive. Just in the same way as Pinnock's Child's First Book, English Grammar, and Geography, led the way to larger works, so did the catechism of Greek Grammar, or of Hebrew Grammar, lead many a lad to more laborious studies. He bought a small book which was cheap, and promised to be easy; and he was enabled, by its perusal, to judge whether there was sufficient encouragement for his further study.

The works of the Useful Knowledge Society are of a very different class; they are calculated for students of a higher class, and are works of an original character: but although they provide for science and history, they do little for letters or language. They supplied one defect, but they do not meet another. In a country like this, with its peculiar political organisation, the life of a young man is no less occupied in the preparation for his political career than in the attainment of those special branches of knowledge peculiarly useful in his ordinary business. Literature enters largely into his amusements; the composition of lectures, the preparation for the discussion class, the studies for the elocution class, the acquisition of the knowledge of Latin and French, which he neglected in boyhood, or could not then learn,—all these take up much time and attention in the literary and mechanics' institutions, no less than with the self-student; and it is a capital defect to prepare a course of educational works which does not provide for these wants. Indeed, the cause of science would be as much promoted by the completion of the circle of knowledge in this way, as by any direct contribution.

In our view, there can be no greater mistake, so far as higher or supplementary education is concerned, than the restriction to empiric instruction. As all the law codes written do not embrace all the forms of litigation, and as all the medical works do not embrace all the cases of disease, so neither can all the books ever written meet all the contingencies of practice. The lawyer, the surgeon, or the engineer, is called upon to act for himself—and then it is he wants something beyond his books. The best works on geometry, and the best works on algebra, will be insufficient of themselves alone to constitute sound reasoners; and they too often have the tendency to narrow the mind rather than to enlarge it. When from abstractions or recognised definitions we come to language, the ambiguous vehicle of thought, the self-taught mathematician is found as perverse, as prejudiced, and as unsound, as any other imperfectly educated man. It is for this reason we object to mutilated studies and mutilated schemes of educational works, when too there is so much to be done. We are sure the Useful Knowledge Society would have done great good in producing uniformly with their other books, good treatises on logic and rhetoric, an idiomatic English grammar, a manual of philology, grammars of the modern languages in conformity with modern science, a work on drawing, as an instrument for training in habits of observation, some decent compositions on political geography,—aye, and they might go further, and let the public know something of ethnology, ontology, the study of the fine arts, the art of teaching, and many other things, old and new, on which there are no good and cheap popular works.

The French have a cheap popular series called the Manuels Roret, ranging in price from two shillings to four or five, which include not merely every branch of science, but every trade and profession. Charles Knight has published some small manuals for trades, but we still want a class of works to answer the purpose of the Manuels Rorets; indeed, had not other occupations prevented us, we should long since have carried out the design we had formed of publishing such a series.

Chambers's Elementary works go almost as low down as Pinnock's in the class for whom they provide, and are nearly as extensive in their range of subjects. Although they have made many branches of knowledge popular, they are rather to be ranked as compilations than as original works.

We have hinted we prefer, as far as possible, works of an original character, rather than simple abstracts of other writings; and do prefer such, because a work of education should be expressly written for the class which it is intended to benefit. The writer, too, must write more with the mind of a student than an author—he must begin as a beginner, and not as a master: and yet that is seldom to be found in any of these elementary works which we have seen. They are rather abridged works of reference, of the class of Maunder's 'Treasuries of Knowledge,' than finished introductions to study. The fear of being tedious, the shame of being tautological, the love of praise, and perhaps the vanity of frippery and fine writing, dazzle and delude the author—and the student is lost sight of. Then, too, one who has learned quickly and well is often a bad master,—to him the manner of teaching and learning is indifferent, for he could learn any way: but not so with the student. Indeed, too much care cannot be taken in this, which is the right way; whereas now, half the care is thrown away because it is bestowed in the wrong way.

Mr. Weale's series certainly does not sin under the head of originality, for many of its parts are already standards in their respective branches; and, as with the Penny Cyclopædia, we shall see that a cheap and popular work may well be a good one, and a step in the cause of science.

We have said so much of elementary works generally, that we have left ourselves but little room for Mr. Weale's individual contribution, which is a very useful one. A cheap dictionary of terms was much wanted, for the field of engineering exertion is now so wide, and the two kindred pursuits of architecture and engineering have so many points of contact, that to most people, and particularly the public, such a guide was indispensable. The author has many peculiar opportunities for such a compilation, and he has fully availed himself of them, so as to embrace much interesting and valuable matter. If he has been occasionally discursive, he has claimed the privilege beforehand, and has therefore the right to be so. There are many things to be found which are elsewhere only to be met with in expensive works.

A Visit to the United Service Institution. By Lieut. D. B. Shaw, K.S.F. London: Parker and Co., Whitehall. 1850.

This little *brochure* should be read *after* the visitor has once gone over this interesting museum, and, as admission is so easily procured, revisit with this work in his hand, and examine more carefully the various subjects he treats upon. The author appears to make one of the party visiting the Institution, and points out everything of interest, doing away with the monotony of a catalogue, as he explains the most rare and curious specimens that are in the museum: the description of the uses of the different arms employed in ancient warfare is most interesting, and those of the South Seas and adjacent countries, together with those of India and China, show that he has made himself familiar with his subject. His description of the Naval and Military Model rooms are invaluable to the student destined for the profession of arms, as he points out many useful hints that might otherwise be overlooked. The specimens of Natural History are given to the visitor in order to bring under his notice those animals and reptiles with which some anecdote is attached. The Antiquities and Ethnological collection has been most masterly handled, and the anecdotes connected with the different subjects most amusing. The Library, which appears to be the *sanctum* of the members, seems replete with every work connected with the services.

The author's object has been to arouse the lethargic spirit which appears to pervade the services, and, as he truly states that this is the *only* Institution belonging to them, he calls upon those officers who compose her Majesty's service, to rally round it as a standard, and give it that support it ought so deservedly get from the profession.

SIR ISAMBERT MARC BRUNEL.

We have to record the death of this celebrated engineer, which melancholy event took place on the 12th ult. For the following memoir we are indebted to the *Times*:—

Sir I. Brunel by birth was a Frenchman, but his life and genius were almost wholly devoted to the invention and construction of works of the greatest public utility in this country. He was born at Hacqueville, in Normandy, now in the Department de l'Eure, in the year 1769; a year since remarkable for having given birth to many eminent men. His family has for many centuries held, and now hold, the estate on which he was born; and the name of Brunel is found constantly mentioned in the ancient archives of the province. He was educated for the church, with the prospect of succeeding to a living, and was accordingly sent at an early age to the seminary of St. Nicain, at Rouen. But he soon evinced so strong a predilection for the physical sciences, and so great a genius for mathematics, that the superiors of the establishment recommended he should be educated for some other profession than that of the church. His father strongly objected to his adopting the profession of an engineer, as one more likely to prove beneficial to others than himself, and he therefore determined that he should be educated for the naval service, in which he thought his son's proficiency in mathematics might lay the foundation of his advancement in that profession. At the proper age he entered the royal navy, being indebted for his appointment to the Marechal de Castries, then the Minister of Marine. On one occasion he surprised his captain by producing a sextant and quadrant of his own construction, and which he used for making observations. He made several voyages to the West Indies, and returned home in 1792. At this time the French Revolution was at its height. As Mr. Brunel entertained Royalist opinions, which he was not very careful to suppress, his life was more than once in danger, and he was, like many others at that time, forced to seek safety in flight. He emigrated to the United States, where necessity, fortunately, compelled him to follow the natural bent of his mind, and to adopt the profession of a civil engineer. He was first engaged to survey a large tract of land near Lake Erie. He was employed in building the Bowery Theatre, in New York, which not many years ago was burnt down. He furnished plans for canals, and for various machines connected with a cannon foundry then being established in the state of New York. About the year 1799 he had matured his plans for making ship blocks by machinery. The United States was not then the field for so inventive a genius as Brunel's. He determined upon visiting England and offering his services and plans for this purpose to the British Government. Lord Spencer, then, we believe, First Lord of the Admiralty, became his friend and patron. He became a frequent guest at Spencer-house, and never failed to speak warmly of the assistance and encouragement he derived from the friendship of Lord and Lady Spencer. From this time he continued to reside in England, and refused to entertain many propositions made to him to leave England and settle abroad under the auspices of other governments. After much opposition to his plans, for a very powerful interest was arrayed against him, not lessened in that day by his being a Frenchman, he was employed to execute them in Portsmouth dockyard. To perfect his designs and to erect the machinery was the arduous labour of many years. With a true discrimination, he selected Mr. Henry Maudslay to assist in the execution of the work, and thus, possibly, was laid the foundation of one of the most extensive engineering establishments in the kingdom, and in which, perhaps, a degree of science and skill has been combined and applied to mechanical invention and improvement scarcely exceeded by any other in the world. The block machinery was finished in 1806, and has continued ever since in full operation, supplying our fleet with blocks of a very superior description to those previously in use, and at a large annual saving to the public. It was estimated at the time that the saving, in the first year, amounted to 24,000*l.* per annum; and about two-thirds of that sum were awarded to Mr. Brunel. It is needless to describe the originality and beauty of this well-known machinery. Even after the lapse of 40 years, notwithstanding the marvellously rapid strides we have made in the improvement and construction of machines of all kinds, it remains as effective as it was when first erected, and unaltered. It is still an object of admiration to all persons interested in mechanics. A few years afterwards he was employed by government to erect saw-mills, upon a new principle, in the dockyards of Chatham and Woolwich. Several other inventions were the offspring of his singularly fertile mind about this time,—the circular saw, for cutting veneers of valuable woods; and the beautiful little machine for winding cotton thread into balls, which greatly extended its consumption. About two years before the termination of the war, Mr. Brunel, under the countenance of the Duke of York, invented a method of making shoes for the army by machinery, the value and cheapness of which were fully appreciated, and they were extensively used; but the peace of 1815 lessening the demand, the machinery was ultimately laid aside. Steam navigation also at that time attracted his attention. He was engaged in the building of one of the first Ramsgate steamboats, and, we believe, introduced the principle of the double engine for the purpose. He also induced the Admiralty to allow him to build a vessel to try the experiment of towing ships out to sea, the possibility of which was then denied. Many other objects of great public utility occupied his mind, which in this mere outline of a long and active life must be excluded.

The visit of the Emperor Alexander to this country, after the Peace, led him to submit to the Emperor a plan for making a tunnel under the Neva, where the accumulation of ice, and the suddenness with which it breaks up on the termination of winter, rendered the erection of a bridge a work of great difficulty. This was the origin of his plan for a tunnel under the Thames, which had been twice before attempted without success. In 1824, however, a company was formed, and supported by the Duke of Wellington, who took from first to last a deep interest in the work. Many men of science also joined it, amongst whom the late Dr. Wollaston was the most prominent, and whose brother long continued one of the most active and able promoters of the scheme. The work was commenced in 1824. It was stopped more than once during its progress by the breaking in of the river, and more effectually at last by the exhausted finances of the company, which never extended beyond the command of 180,000*l.* At length, after the suspension of the work for many years, by a special act of Parliament, a loan was sanctioned. The Exchequer Loan Commissioners advanced the funds necessary for the completion of the work under the river, and, notwithstanding many weighty professional opinions were advanced against the practicability of the work, from both the loose alluvial nature of the soil through which it had to be constructed, and the superincumbent flood of water, it was finished and opened to the public in 1843. In a scientific point of view this work will always be regarded as displaying the highest professional ability, an amount of energy and perseverance rarely exceeded, and a fertility of invention and resources under what were deemed insurmountable difficulties, which will alwys secure to Sir I. Brunel a high place amongst the engineers of this country. During Lord Melbourne's administration Mr. Brunel received the honour of knighthood, on the recommendation of the late Lord Spencer, then Lord Althorp.

Sir I. Brunel was a vice-president of the Royal Society, a corresponding member of the Institute of France, and a vice-president of the Institution of Civil Engineers. He was a Chevalier of the Legion of Honour. He was unaffected, simple in his habits, and benevolent, and as ready to do a kind act as he was to forget an injury. He died in his 81st year, after a long illness, which first visited him soon after the completion of the Tunnel. The care, anxiety, and constant strain of body and mind, brought on a slight attack of paralysis, from which he never thoroughly recovered. He leaves a widow, Lady Brunel, one son, the eminent engineer, and two daughters, the eldest married to Mr. Hawes, the Under-Secretary of State for the Colonies, and the youngest to the Rev. Mr. Harrison, the vicar of New Brentford.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

INSTITUTION OF CIVIL ENGINEERS.

Dec. 4, 1849.—JOSHUA FIELD, Esq., President, in the Chair.

The discussion was continued on Mr. PATON'S "*Description of the Southend Pier, and the ravages of the 'Teredo Navalis,' and other Marine Worms.*" and was extended to such a length as to preclude the reading of any original communication.

Numerous specimens were exhibited, and commented on, of timber thoroughly perforated by worms; whilst beside them, under the same circumstances, the "Jarrow wood," from Australia, was shown to have remained completely free from injury.

The reference to the age of Homer, as an instance of the ravaging habits of the *Teredo*, induced a return to geological questions; and it was shown that in the London clay, remains had repeatedly been found of timber perforated by sea worms. The oolite and greensand formations also exhibited petrified wood, filled with boring moluscæ. This led to the consideration of the formation most likely to withstand the attack of the *Pholas;* and it was shown, that the Portland stone was, from the quantity of silica it contained, least liable to be attacked.

The *Pholas* was shown to have been in active operation upon certain rocks from their earliest periods, but never upon Portland stone. Hence it was argued, that kind of stone should be used for breakwaters and other works exposed to the action of the sea.

The early state of the *Teredo* was noticed; when escaping from the egg, in the shape of a free swimmer, it was drifted about with the tide until it met with a log, a pile, or the side of a ship, to which it attached itself, and making an inroad into it, became a non-locomotive animal of different form and habits, never again to leave the habitation it had burrowed for itself in the body of the timber. The question of whether the boring operation of the marine worms was carried on by chemical, or mechanical means, was lengthily discussed. The thin shell, covered by its delicate membrane, was instanced as not possessing strength enough to cut away timber; but it was on the other hand shown, that the shape of the two shells, forming the extremity of the animal, admirably adapted them for powerful cutting, or rasping tools, when moved rapidly in a circular direction, as was evidently the case, from the uniformly cylindrical character of the holes.

The shells of the *Pholas* were also shown to be used in that manner, and the opinion appeared generally to lean to mechanical cause for the effects observed.

This bearing of the discussion naturally induced remarks upon the ravages of the white ant of India; which, however, appeared to have been little studied, and less understood, as far as attempting to arrest, or to prevent its inroads.

The various materials, such as Kyan's corrosive sublimate of mercury, Sir W. Burnett's chloride of zinc, Margary's salts of metals, Payne's combination of muriate of lime and sulphate of iron, forming in the timber an insoluble compound, and Bethel's creosote, or oil of coal tar, were discussed. All had their partisans, and were stated to have succeeded and failed under certain circumstances. Specimens of piles from Lowestoft harbour, whose waters were notoriously full of worm, showed that timber in a natural state was in a few months thoroughly perforated by *Teredo* in the centre, and *Limnoria* on the surface; but that piles, which had been properly saturated according to Bethel's system, in exhausted receivers, and subjected to such pressure as insured the absorption of about ten pounds' weight of the creosote, or oil of coal tar, by each cubic foot of the timber, were perfectly preserved from attacks of marine animals of any kind.

In one instance a partially "creosoted" pile had a notch cut into it, deeper than the impregnation had extended; a *Teredo* made its entry, and was found to have worked in every direction, until it arrived within the reach of the creosote, when the animal turned away and eventually left the pile.

Bethel's system was admitted, by all the speakers, to be that which hitherto, after many years' experience, had afforded the most satisfactory results.

Some most conclusive experiments, instituted by Mr. Rendel at Southampton, were stated to have produced the same results; and at Leith all the piles were weighed before and after their saturation, to insure their absorbing the full allowance of at least ten pounds per cubic foot.

Dec. 11.—The paper read was "*On the facilities for a Ship Canal Communication between the Atlantic and Pacific Oceans, through the Isthmus of Panama.*" By Lieut.-Col. LLOYD, Assoc. Inst. C.E.

In treating this subject, which, on account of recent events, has become one of great importance to the political and the mercantile world, the author brought to bear all the knowledge and experience acquired during a lengthened residence in South America, when serving in the Columbian Engineers, under General Bolivar, from whom, after much difficulty, he obtained permisson to make the first survey of the Isthmus, which he accomplished in the most complete manner, as well as making soundings throughout the principal rivers and in the chief harbours; compiling, at the same time, a mass of minute and valuable information relative to the country, which he transmitted to the Royal Society, in whose archives they were deposited, and a paper on the subject was published in the *Philosophical Transactions* in 1830. Thus may Great Britain claim not only the projection of one of the greatest works of modern ages, but also for one of her sons the merit of having, for the pure love of science, been the first to demonstrate the facility of the accomplishment of that, which so many have since descanted upon, and, to some extent, appropriated without acknowledgement.

The general views of the author incline to the formation of a ship canal, in preference to a railroad; he denies that there are any obstacles to its accomplishment, but, on the contrary, asserts so many local advantages to exist and to be concentrated nearly at one point, that in after ages it will be a matter of wonder why so many generations should have neglected, or refused to render them available, towards the establishment of this long-coveted communication between the two Oceans.

The paper first reviewed the surveys of Garella, of Morel, and others, who had examined the country subsequently to Colonel Lloyd. It then examined the various lines proposed, and gave reasons for preferring that which, starting from the beautiful Bay of Limon, would proceed by a short canal, through a flat country, to the River Chagres, thence up the River Trinidad, as far as its depth would suit, and then cutting a canal into the Rio Grande, debouching at Panama. This line, it was contended, in the present state of the science of engineering, presented no obstacles, excepting the climate and the expense, to prevent a canal being cut of sufficient depth and dimensions to float, from one river to the other, the largest ship in her Majesty's navy.

The climate was stated, from personal experience, to be quite as good as in any tropical country, except in some particular spots, where, from local causes, certain complaints were rife.

The expense could only be accurately estimated by the survey of experienced engineers; but in a country abounding in fine timber, and the best building materials of all kinds, whilst no great chain of mountains, as had been fancifully depicted on suppositious charts, had any existence except in the imagination of the designer, it was only fair to allow, that the cost of a canal of such limited length could not be very great, and the supply of water might be presumed to be ample, in a climate where there was copious rain for nine months in each year.

The disadvantages of a railroad in such a humid climate, were descanted upon at length, and it was shown that the risk of injury to merchandise from that cause alone, independent of that to be anticipated from breakage and pilfering, during the various transshipments, must induce preference for a canal, through which vessels should pass from sea to sea without delay, and continue their voyage to their destination without breaking bulk.

The means of accomplishing the work were then fully considered. The proposition for a certain number of convicts, to be contributed by Great Britain, France, and America, was shown to be untenable; but it was argued, that a portion of the convicts from this country might be more advantageously sent there than to our present penal settlements. The means of preventing their escape were shown, and a proposition made for introducing with them a number of convicts from Bengal, and the other presidencies, whose language and habits would effectually prevent their mingling with the British convicts, whilst their power of enduring fatigue under a tropical sun, and during rains, and their simple mode of living, would render them valuable pioneers for the more robust Englishmen. It was stated also, that a great deal of native labour might be obtained at a cheap rate; sixpence, or ninepence per day, and his rations, consisting of a pint of rice, a pound of dried beef, and a *golpe d'aguardiente*, being the ordinary pay of a "Peon." The chief point, however, insisted on by the author, was the great field opened in the Isthmus, for emigration for the surplus population of this country. He contended, that it was far preferable to the Canadas, where the poor but industrious and honest mechanic, or labourer, on arriving, found that the rich lands he had heard of could only be reached by a weary journey, and after such hardships, in a severe climate, as his limited means and broken strength rendered impossible for him to bear. Australia, with its arid, trackless wastes, held out still fewer temptations to the emigrant; for the ordeal of misery to be enumerated by the majority, was such as to deter all but the stoutest hearts from encountering it. The Isthmus had none of these disadvantages. It was comparatively within an easy distance; the emigrant would be at his destination almost on landing; the resources of the country were great, and the productions varied and cheap, whilst the present population was infinitely disproportioned to the superficial area of the country. This point was strongly insisted on, and it was argued, that a grant of land might be easily obtained, in liquidation of the debt owing by the government of the country, and as the British had once possessed an establishment there in 1675 to 1690, under the charter of the "Scotch Darien Company," so a footing being again obtained, a barrier of the most formidable character would be opposed to the annexation propensities of our transatlantic brethren, who were making rapid strides towards the possession of this valuable tract.

Appended to the paper, was a copy of the commission granted to Lieut.-Colonel Lloyd, by General Bolivar, authorising his examination and survey of the Isthmus, and of the rivers, which had previously been most jealously refused to every one. This document was alluded to with some natural pride, as proving, that to an English engineer was due the merit of having been the first to examine and propose a work of such vital importance to the whole world, but which had been since claimed, and in fact, appropriated by other persons without acknowledgment.

Dec. 18.—The annual general meeting of the Institution was held on Tuesday evening, December 18th, when the following gentlemen were elected to form the Council for the ensuing year:—

William Cubitt, *President;* I. K. Brunel, J. M. Rendel, J. Simpson, and R. Stephenson, M.P., *Vice Presidents;* J. F. Bateman, G. P. Bidder, J. Cubitt, J. E. Errington, J. Fowler, C. H. Gregory, J. Locke, M.P., I. R. M'Clean, C. May, and J. Miller, *Members;* and J. Baxendale and L. Cubitt, *Associates of Council.*

The Report of the Council, which was read, alluded to the past season of unexampled depression in the engineering world, but at the same time held out hopes of improvement, on account of the agitation of the subjects of better supplies of water and gas, the sewerage and drainage of towns, the construction of abattoirs, and other sanitary questions; whilst the improvement of canals, in their struggle with the railways for the heavy traffic, the construction and amelioration of harbours, the embanking and improving of rivers, the recovery of marsh-lands from the sea, and numerous other works, which had been neglected on account of the more attractive railways, would resume their former importance, and eventually afford ample employment for the majority of the members of the profession.

It was shown, that the careful administration of the funds had been attended to, and that a considerable quantity of publications had been issued.

The alteration of the commencement of the session was shown to have worked well; and, in general, the report of the progress of the Society was very satisfactory, in spite of the bad times for engineers.

The debt contracted for the improvement of the House of the Institution was stated to have been entirely liquidated, by the liberality of a number of the members.

Telford Medals were presented to Lieut.-Colonel Harry D. Jones, R.E., Mr. R. B. Dockray, and Mr. J. T. Harrison; Council Premiums of Books to Messrs. J. T. Harrison and J. Richardson; and Telford Premiums of Books to Messrs. R. B. Grantham, T. R. Crampton, W. Brown, and C. B. Mansfield; the President addressing a few complimentary expressions to each of these gentlemen on presenting the premiums.

Memoirs were read of the following deceased members:—Messrs. J. Green, P. Rothwell, R. Sibley, and D. Wilson, Members; A. Mitchell; Lieut.-Colonel A. W. Robe, R.E.; C. K. Sibley, W. Mitchell, and J. C. Prior, Associates; and J. Woods, Graduate.

The following extract from the Memoir of Lieut.-Colonel A. W. Robe, will give a specimen of the manner in which civil engineers treat and speak of the memory of their deceased brethren, whether civil or military:—

"Lieut.-Colonel Alexander Watt Robe, R.E., was born at Woolwich, on the 31st of January, 1793; he commenced his military career, as a gentleman cadet, at Great Marlow, removing from thence to the Royal Military Academy at Woolwich, and obtained a commission in the corps of the Royal Engineers, in 1811; finally attaining the rank of Lieut.-Colonel in that distinguished corps, in 1837. By a remarkable combination of circumstances, although he was continually appointed for active service, his appearance was generally the harbinger of peace. He joined the army of the Pyrenees in 1813, just before the termination of the war in the Peninsula; and in 1814 was attached to the forces under Sir Edward Pakenham, in the expedition to New Orleans, but only arrived at the cessation of hostilities. Immediately on his return to England, he received orders to re-embark for the Netherlands, but only reached the seat of war a few days after the battle of Waterloo. He remained with the Army of Occupation until 1818, and shortly after his return was appointed to the Ordnance Trigonometrical Survey, the duties of which post he performed with great skill and ability, until 1841, when he proceeded to Halifax, Nova Scotia, as second in command of the Royal Engineers; and in 1843 was appointed Commandant of the Royal Engineers at St. John's, Newfoundland, in which command his honourable and useful career terminated, with his valuable life, on the 2nd of April, 1849, which was shortened by disease, originating in over-exertion on the survey in the North of Scotland, and aggravated by fatigue during the great fire at St. John's, where he toiled incessantly for forty-eight hours, in protecting the lives and property of the inhabitants.

"Colonel Robe was descended from a line of ancestors who had all been in the military and naval services; his four brothers were also distinguished officers, and two of them fell gloriously in the service of their country. He was devotedly attached to scientific pursuits, and was eminently useful in promoting the object of the societies which he joined, and for this his mathematical acquirements and topographical knowledge peculiarly qualified him. He was elected an associate of this Institution in 1838, and served on the council for some years, with great zeal and attention, being continually present at the meetings, and inducing the frequent production of original papers, or presents of charts, &c., for the collection.

"In the performance of his military and civil duties, his zeal and ability were unbounded; as a son, a brother, and a friend, he could not be surpassed, and the public estimation in which he was held, was fully testified by the general mourning for his loss, at St. John's, Newfoundland, where he died, and where it was said of him that 'it seldom fell to the lot of a military man to be so beloved by civilians.' The secret of this respect and esteem was the active and untiring benevolence of his character, which was only equalled by his unassuming manner, and the frankness and mildness of his demeanour; and the highest eulogium that can be paid is, that 'those who knew him best, esteemed him most.'"

The thanks of the Institution were voted unanimously to the President, Vice-President, Members, and Associates of Council. to the Auditors, Scrutineers, and the Secretary, for their attention to the interests of this Institution.

The President returned thanks very briefly, and on retiring from the Chair, after holding it most worthily for the two past years, he recommended to the members his successor, Mr. Cubitt, whose active energy and high position in the profession, rendered him every way fit to occupy the Chair of such a society.

The address was very warmly received, and it was proposed to the council, to consider by what means the eminent past Presidents could be enabled to continue their valuable services, in conjunction with the acting council.

ROYAL SCOTTISH SOCIETY OF ARTS

Nov. 26, 1849.—THOMAS GRAINGER, Esq., President, in the Chair.

The following communications were made:—

1. At the request of the Council an Experimental Exposition was given, containing his "*Concluding observations on the 'Strength of Materials' as applicable to the construction of Cast or Wrought-Iron Bridges, and on the Conway and Britannia Tubular Bridges* (Part II.), *being an account of the method of raising the Tubes of these Bridges.*" By GEORGE BUCHANAN, Esq., F.R.S.E.

In this concluding paper Mr. Buchanan commenced by giving the result of an interesting experiment, made since the former evening, on the transverse strength of Caithness pavement. The results of the experiments already shown on slabs 9 inches broad, 3 feet deep, and 3 feet long, were as follows:—

Hailes	794 lb.
Craigleith	1148
Arbroath	1848

The Caithness pavement was rather less in dimensions than the others, being only 8¾-inches broad instead of 9 inches, and 2¾ deep in place of 3 inches. From the previous experiments on the tensile and compressive strength of Caithness pavement, he had hardly expected it would equal the Arbroath; but it was found greatly to exceed it. After piling on stones and brick to the extent of 25 cwt., the frame, being of a temporary nature, gave way, but with all the concussion the stone was not broken; and on trying it again with a stronger frame, it carried for nearly half a minute 29 cwt. 1 qr. 15 lb., and then gave way. This specimen, he understood, was from the hardest of the quarries, and he has no doubt there are considerable diversities, which shows the importance of these experiments, and of continuing and extending them with every opportunity. The unit of strength from these experiments is easily deduced by taking the breaking weight of each specimen, multiplying it by the length, and dividing by the depth and by the section of fracture. The results are as follows:—

	Units of strength.
Hailes	353 lb.
Craigleith	510*
Arbroath	821
Caithness	1500

Mr. Buchanan then proceeded to complete his description of the lifting of the Britannia Tubes.

The main process of lifting was completed previous to his visit, and the tube raised to its place; but as it still required some finishing adjustments in the bed-plates, he had an opportunity, when there, through the kindness and attention of Mr. Clarke, of witnessing this great and interesting operation; and it was truly gratifying to observe the simplicity and perfect action of the machinery by which it was accomplished, the movement of the small engine and piston being smooth and easy, while the gigantic mass of the tube rose slowly and majestically to the place required. The ascent to the lifting machinery is first by long ladders in the dark hollow or void within the Britannia Tower. This brings us to the level of the bottom of the tube, and from thence the ascent to the top is by similar ladders in open day, resting on the sides of the tube, and, when ascended, we attain an elevation of 133 feet above high-water mark, and nearly 150 feet above low water; and in walking along the top of the tube, between the towers, there being no railing, the gusts of wind at such an elevation appear at first rather alarming, yet it is curious to remark, that immediately on the surface of the tube, and for several feet above it, a comparative calm prevails, owing to the wind impinging upon the sides and flying over head; so much so, that he was informed, even in a very strong wind, a lighted candle could be carried near the surface of the tube all the way without being extinguished.

He then illustrated the process of lifting by drawings on a large scale, and models of the Bridge and Towers, and an enlarged model of the lifting apparatus; all which exhibited very clearly the whole details of the operation. It is accomplished by hydrostatic power, worked by steam-engines, which are all erected and fixed on the top of the towers, the engines giving motion to small force-pumps by which water is forced with an intense compression into the interior of large cylinders, which again communicate this pressure with increased effect on the enlarged surface of the pistons or rams which move up and down within these cylinders, and at each ascent are capable of bearing a most enormous load resting on the top. In the Britannia Tower there are two of these cylinders and rams, standing about 6 feet apart, and carrying a vast beam of cast-iron, resting at each extremity on a shoulder on the top of the ram, and extending between them, in one solid mass, 4 feet deep, and a proportional thickness, and strengthened along the bottom by very strong malleable iron ties.

The rams being made to rise simultaneously, the whole beam rises with a slow and regular motion, bearing up whatever may be attached to it. The pressure of the water within the tubes is capable of being raised as high as 450 atmospheres, or 6,700 lb., or 3 tons and upwards per square inch; and the area of each ram, which is 18 inches diameter, being 260 inches, the combined effect of the two rams is capable of lifting upwards of 1,500 tons.

But all this machinery and power would be of no avail, unless it had a proportionally firm and secure place to stand on, and to bear up the weight of the machinery itself, and in addition to this, the 1,500 tons which it is capable of lifting. For this purpose, two very massive beams or girders, not of cast-iron, but of malleable iron, are extended across the recess or opening in the tower, resting at each extremity on strong masses of cast-iron, or wall boxes built solidly into the masonry. These beams are 21 feet long, 4 feet deep, and 18 inches thick, consisting of a mass of plates laid together and firmly bolted, and the whole, being of malleable iron, gives great additional security and confidence.

To communicate the above power of the presses to the tube, which, after being floated, is still situated 120 feet below the level of the pumps and presses, two enormous chains, consisting of long and short links of flat plates, descend from the cross beam or head which rests upon the rams, down to the extremity of the tube to which they are attached; very particular arrangements are necessary for attaching these chains to the tubes. For this purpose, the extremities of the tube are strengthened at the sides by three strong cast iron pillars or frames, standing upright on each side of the tube, and rivetted to the thin sides of it, and connected by cross beams to the top and bottom, so as to form each one entire rectangular frame, fitting the interior of the tube. These frames are necessary, in the first instance, for strengthening the tube itself; for, strange as it may appear, though the tube carries an enormous load in the centre, yet at the extremities where it rests on the piers, and where the whole pressure is thrown and concentrated upon the thin sides, it would not, without aid, carry its own weight; it would fall to pieces in a moment by the accumulated pressure; and it was found, on the remarkable occasion of the bursting of the cylinder, though the tube only descended a few inches, such was the effect of the concussion, that these pillars and frames were fractured and shivered to pieces. It is by these frames, then, that a secure attachment is obtained for the lifting chains, and for this purpose three additional cross-beams are extended at intervals be-

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* It was here suggested by Mr. Black, architect for Heriot's Hospital, that these experiments would probably not give a fair criterion of Craigleith stone, as he conceived the strength would be very much diminished by the hammering and chiselling necessary to reduce it to a 3-inch thickness, and that if the trials were made upon larger masses a greater unit of strength would, he thought, be found applicable to them. It was explained, however, that the above specimen was not from the liver rock of the quarry, but from the common rock; and, as afterwards stated by Mr. Notman, who furnished all the specimens, from what is called the pavement flakes, which run in parallel beds from 4 to 6 inches thick, the same way as the other pavements. It was 4½ inches thick when taken out of the quarry; and the reduction, Mr. Buchanan did not think could affect the strength on the above general result. The liver rock would have borne less than the specimen.

tween the top and bottom of the outside frames, and to each of these the chains are attached, so as to have a secure hold of all the three together.

Every provision and proper attachment being now made for the lifting, there is nothing to prevent the process going on. But as the rams are only capable of rising 6 feet, another arrangement still remains to be explained, and which is a curious one, and has admirably answered the purpose. Unless the rams and their cross-bearing beam had a very secure hold of the chains, nothing would be safe; and yet when the rams have ascended to the top of their stroke, they must let go this hold, otherwise nothing farther can proceed. The chains, therefore, must be detached from their hold of the bearing beams. In order to provide for this detachment, the chain, instead of being bolted or fixed to the beam, is merely passed through the centre of it, and the top of each link having a square shoulder formed upon it, two moveable or sliding blocks are laid on the top of the beam, capable of being moved by screws, more or less apart, so as to come under the shoulder of the link, and being screwed hard up, it forms a complete, and yet not a permanent, attachment for the chains. When the rams, therefore, have completed their lift, the chain is detached from its seat on the top of the beam by unscrewing these sliding blocks; but unless some farther provision were made for supporting the chain and tube—while it is detached from its bearing on the rams, the whole would fall to the ground. A second set of sliding blocks, therefore, is provided, resting on the top of the malleable iron beam, which carries the whole machinery, and the links of the chain being made exactly 6 feet in length, the lower sliding blocks are placed exactly 6 feet below the upper, so that the moment the rams have raised the chains 6 feet, it brings the shoulder of the next lower link level with the lower sliding blocks. These being then screwed together, lay hold of the chain at the bottom of the link, and keep firm hold until the blocks are detached from the top. The rams are then allowed to descend by letting off the water pressure, and having reached the bottom of the stroke, the sliding blocks then become level with the shoulder of the next link lower in succession. The upper blocks being then screwed up and the lower blocks detached, the rams again rise by the internal pressure communicated by the pumps and engine, and again carry the tube and all its appurtenances 6 feet higher, and the same operation is repeated by 6 feet lifts in succession, until the whole height is attained. When the chains ascend above the level of the rams, each link, as it rises above the level of the bearing beam, is taken down and removed out of the way by unscrewing the bolts.

The opening and shutting alternately of these blocks is all contrived ingeniously, so that the four ends of the two blocks, which have each separate movements, are yet all made to approach or recede by the turning of a single handle and pinion-winch, so as greatly to facilitate the process. On the Anglesea Tower there is only a single press, the ram being 20 inches in diameter. The single power has one advantage, that acting in the centre of the tube, this must be raised simultaneously and equally at both sides. In the double power, which possesses other advantages, there is some risk of the tube rising unequally at the sides, and turning off the perpendicular. To avoid this, an assistant is stationed at each ram, who observes on a scale, and calls out every inch as the rams ascend, and thus an equality is maintained. The opposite ends of the tubes might be lifted simultaneously by having the opposite engines and rams at work together, as was the case in the Conway; but this is liable to produce an oscillating movement in the whole tube, which it is desirable to avoid; so the lifts are made at each end alternately. As the tubes ascend at each end, care is taken to follow these up with layers or plates of timber or iron, piled up uniformly to within an inch or two of the bearing beam, so that in the event of anything going wrong, the tube would fall and rest on this packing, and do no injury.

In regard to the strength of the tube, Mr. Buchanan gave the result of some experiments, communicated by Mr. Clarke, on the strength of malleable iron. It had formerly been considered from those of Telford and Brown that malleable iron would bear 27 tons on the square inch, but these experiments were made with hydraulic or lever power, which is affected by the anomalies of friction. Clarke's experiments are not liable to this objection, as they were made by direct tension, by heaping on masses of iron or other weights till fracture took place, and from them it appeared that the average strength of malleable iron cannot be reckoned greater than 20 or 21 tons per square inch.

Some remarkable experiments were also made on rivetted plates. It had hitherto been considered, and very naturally, that the tensile strength of rivetted plates must be diminished by a quantity equal to the aggregate section of the rivet-holes, which being pierced through the metal, must, as was assumed, detract from its strength. Mr. Clarke, however, has found by careful trials, that when the bolts are put in red hot, and quickly and properly rivetted, that the contraction of the iron in cooling is such as to compress the plates together with a pressure about 5 tons to the inch, so as to require an enormous power to make the plates slide one upon another, and the heads being, moreover, so closely compacted into the plate, the bolts also resist this sliding by the power of detrusion,—in proof of which, these bolts, in cases of fracture, are often seen cut clean across as if by the shears. But whatever may be the cause, the result is, that he considers the rivetted portion of the plate as strong as the solid. These experiments, therefore, though contrary to the received notions, are highly important; they give additional confidence to the structure of the bridge, and are also extensively applicable in various cases of steam boilers and others.

He then explained particularly another remarkable circumstance in the structure of the bridge—namely, the uniting of the two great central tubes of the Britannia Tower. This was proposed to be done by inserting a small middle portion of tube in the Britannia Tower, so as, by this connecting link, to unite the two extremities of the opposite tubes in one continuous mass; and, in order to give full effect to the principle, it was proposed, before rivetting the last and final joint, to lift the extreme end of the tube resting on the land tower 12 inches or more, while the joint was making, and then let it down again to its place. The effect would be, by the two tubes pulling against one another, and distending powerfully the upper side of the tube in the Britannia Tower, that the deflection in the two opposite tubes will be diminished, and the strain, instead of being borne by the central portions of the tube, would be distributed, and shared by the whole of the section at the extremities in the Tower, where the depth is the greatest, being there 30 feet.

This was a happy idea, and he had no doubt it would be successful; it would have the effect, indeed, if all the ends were united, that though one of the central tubes were cut across at the middle, it would still hang by the extremities and sustain a very great load; and he explained particularly the nature and effect of the strains on a beam in this situation, which resembled in fact a continuous beam or flooring deal passing over several bearings or joists intermediate between the walls, or like the rails of a railway resting on its chairs. It is well known that the continuous beam is much stronger than if it were cut across at any of the intermediate joists, and the rails are subject to greater deflection in the space next the joint chairs, which, on this account, are brought closer together. Now, it is important to remark, in the case of such a beam, not merely supported at the ends, but fixed or attached longitudinally to another beam, that the whole of the particles on the upper side of the beam are not subject to a compressive force according to the general notion, but are only compressed near the centre. The extremities are subject to violent distention, and the middle parts remain neutral. The true lines of the compressive force resembled exactly that of the rafters of the roof relative to the tie-beam; and this confirmed what he had formerly explained, that the nearer we can approach, in the form of our girders, to this simple figure of a triangular frame, the more perfect would be the distribution of the tensile and compressive forces throughout the material proper for bearing them. On the whole, this arrangement would give great additional confidence in the structure of the Britannia Tubular Bridge; for, in ordinary girders, if there were any imperfection or failure in the centre, nothing could save the structure; but here we have a girder which, though it were cut through the centre, would still bear up the bridge, and any load that might be upon it, by the great strength remaining in the extremities.

Great, however, as is the strength and security of this structure, it should not be forgotten that bridges of this description, and of such enormous spans, could not be executed without great sacrifice of materials, and should not therefore be attempted, unless from absolute necessity, as in the present instance. As we increase the span, the strains on the bridge arising from its own weight and that of the passing loads must increase rapidly, owing to the nature of the transverse strain, even if there were no increase of load; and when we consider that, in addition to this, the bridge itself must be increased in all its dimensions—in length, depth, and thickness—and the passing load increased also in proportion to the length, it is evident that we must quickly approach a limit beyond which the mass of the structure will nearly overpower its strength, and leave no remnant for either load or contingency. This is shown very clearly when we compare the strength of the model tube, as shown by the experiments of Fairbairn, with those of the Conway and Britannia Bridges. The model tube weighed nearly 6 tons and carried 92¼ tons in the centre before breaking, which is equivalent to 30 times its own weight equally distributed. Now, the Conway or Britannia tube, calculating from the experiments on the model tubes, and the data furnished by them, could not be expected to carry more than three or four times their own weight. As the passing load cannot, in the most extreme case, exceed one-fourth part of the weight of the bridge, there is still here an ample margin of strength and security; but yet it appears that if we were to extend our spans much farther we would rapidly approach the limit of safety.

In answer to a question from the President, he explained the mode by which provision was made to allow the tube to expand or contract by heat or cold. This was done by fixing the ends in the Britannia Tower, and causing the tube at the other bearings on the towers and abutments to rest on numerous cast-iron rollers, on which it could easily move backwards or forwards. And, in answer to a question from the Vice-President regarding the means of keeping up continuity in the rails at the extremities of the tube, he did not think any inconvenience was found from this in the Conway, and it was proposed to be provided for in the Britannia Bridge by sliding joints.

The thanks of the Society were voted to Mr. Buchanan for this interesting series of expositions on the strength of materials, which were given to him from the Chair.

2. "*Description and Drawing of a Machine for Mortising, Tenoning, Boring, and Ripping Timber,*" By Mr. WILLIAM R. DOUGLAS.

It was stated that this machine in all its parts possesses great advantage over hand-labour; and, as all the parts are useful for the trade, it is a saving of room and framing to have them connected. The mortising is done by a fly-wheel and double-crank connected to a cross-head similar to an engine, in the centre of which is fixed the mortising-iron, the wood passing under it between two guides, the one fixed and the other elastic, to suit wood of unequal thickness. To tenon, the mortising-iron is taken out, and the frame containing the two saws is fixed to the cross-head. On the driving shaft is fixed an eccentric shove, which communicates the motion to a ratchet fixed on the end of a roller to which is fixed one end of a rope, the other is attached to a slide carriage on which the wood is conveyed to the saws or mortising-iron. To bore, a journal is put into the centre of the cross-head containing the auger, which is coupled to a square iron rod, which is made to move easily through a shove and fly-wheel placed on the top of the framing, the motion to which is communicated from a shove and fly-wheel outside the framing; any amount of pressure may be obtained by adding weight to one side of the large fly-wheel. The motion is communicated to the ripping saw by the large fly-wheel: the cross-head requires to be disconnected during the time of ripping.

3. "*On a method of introducing an abundant supply of Fresh Air into Coal-Mines, and of preventing the accumulation of Fire-Damp therein.*" By Mr. William Shedden, of Leith.

The author gives the following abstract of his method:—Fans have been long used for winnowing corn. They are used for smelting cast-iron in foundries. They are used for blowing smiths' forges. They are used by brewers and distillers for cooling their liquors. They are used for ventilating large buildings. The question occurs—could they not be efficiently used for ventilating coal-mines? Fans being of such general use, their properties are well understood. By their rapid rotatory motion they send off a large current of air from the extremity of the blades, and by which means a partial vacuum is created at the centre. Attach a pipe to this centre and let it go along the roof of all the workings in the mine—thus the enemy will be withdrawn, and a constant circulation kept up. Let another set of fans be put in motion, and pipes attached to the extremity of the fan-box, and these pipes running along the bottom of all the workings, an abundant supply of fresh and wholesome air would be thrown in, restoring the equilibrium, and making it impossible for an explosion to take place. Any one of these fans would do alone, but the two combined would be far more complete. A small engine would answer the purpose, and for the price of fuel, it might be said to be nothing at a coal-mine. I do not think it would be necessary to keep the engine in motion 24 hours in the day, perhaps 12 would be sufficient—a few hours before the miners commence work, and stop when they stop. The pipes alluded to do not require to be strong, nor their joinings to be air-tight. By not being tight they will operate along their whole length.

It is calculated that since the year 1800, more than 20,000 human beings have been killed by explosions in coal mines in this country. In 1847 and 1848, more than 1,200 lives were thus lost, and in 1849, upwards of 700.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Dec. 3, 1849.—Thomas Bellamy, Esq., V.P., in the Chair.

"*On the Ancient Architecture of Scotland.*" By R. W. Billings, Associate; who exhibited a large number of beautiful sketches, forming part of the illustrations of the work on the 'Baronial and Ecclesiastical Antiquities of Scotland.'

Antiquities are to be regarded not merely as objects for date-mongers, but as works of art; as memorials of ancient times, most valuable as illustrating history. The antiquarians of France and Germany—nay, we ourselves, have been too apt to claim great remoteness for their antiquities, but all these are put to shame by the more ancient remains of India and Egypt. As a preliminary remark it was to be observed, that although the principal monuments of both England and Scotland may be identical in minute details; yet, at the same time, great changes and varieties occurred in various leading features, so as to produce a distinct individuality in the character of the Scottish edifices.

The beautiful little Church of Leuchars, in Fife, by some reputed as of Saxon origin, is a fine Norman specimen, with an apsidal east end. The Cathedral at Elgin is a beautiful edifice, and the arcaded streets of that town most interesting, somewhat resembling those of Chester—the arcade, however, being on a level with the street, and constructed of stone. At three miles from Elgin is a curious old fire-proof house, at Coxton, in which the alternate stories are arched, with semi-vaultings, the upper one, however, being pointed. The turrets of Cawdor Castle, near Inverness, are curious, being circular in the lower part and octagonal above.

Mr. Billings considered the first Scotch architectual era to have ranged as in England, from 1066 to 1200. The Abbey and Palace of Dunfermline, and the Cathedral of Kirkwall, are gigantic examples of that period, and they bear a striking affinity to Durham Cathedral, the solid cylindrical columns in the two being identical; and history informs us that Malcolm the Third, in 1093, assisted in laying the foundation of Durham Cathedral, and soon after his return from that place, founded the Abbey of Dunfermline, the first monks of which were from Canterbury. The smaller Scotch buildings of the Norman period approach nearer in beauty to those of England. Among the most beautiful and perfect specimens are the Churches at Leuchars and Dalmeney. An endless variety of detail was presented in Scottish architecture, most remarkable; when not only animals and foliage were introduced, but even the signs of the Zodiac. At the period of the transition to the early Pointed or Lancet, the mouldings of the Scotch buildings became so minute, as to excite almost a feeling of pity for the workman who had to accomplish such a task. Some of the capitals at Holyrood Chapel are a verification of this—the quality of the ornament was, however, equal to the quantity. At a later period, the system became the very reverse, and more effect was produced without mouldings by the use of the chamfer, the splay of the arch however being moulded. The Cathedral of Dunblane is an extraordinary example of the great effect produced by the judicious use of limited means.

Had the ancient friendship between Scotland and England continued to exist, there is little doubt but that the architecture of both would have remained nearly identical; but the complete severance of all friendly ties between the two kingdoms, and the endless feuds among the various clans and even families of Scotland, compelled the lairds to make their houses strongholds of defence, both against their English foes, and the attacks of their own countrymen. This state of things gained for Scotland at least this advantage, that of possessing what no other country can boast of—a complete series of Castellated Architecture. Not only did the clannish constitution of society in Scotland at this time divide the population into very small parties, but the very disposition of the people was averse to large congregations; this may easily be proved by the small size of the ancient portion of Scotland's capital, and of Stirling, the approaches being defended by a strong fortress. The political changes of society have, however, gradually had their effect in Scotland, and the application of steam and machinery have almost entirely changed the state of the country in this respect. Ancient mansions have been deserted and dismantled, and detached houses of the lower classes, and many "towns," as they are called, have been allowed to decay and fall.

It is very singular that Scotland does not now possess one recognisable specimen of a Norman Castle; although, close to her borders, so many are to be found, such as Norham, Bamborough, Newcastle, and Durham. Yet, that such castles did exist, there can be but little doubt; and the only mode of accounting for their disappearance is the supposition that they were sold by the magistrates as quarries, out of which so many of her abbeys were constructed. So determined seems this desire to have been for the destruction of old castles in Scotland, that Caerlaverock is the only example earlier than 1350, and it still retains its corbelled parapet. Kildrummie, in Aberdeenshire, appears to be the first recognisable Scotch castle, and was built about 1270 to 1300, belonging to the early English style. One side is exceedingly singular, forming the end of a church with three lancet windows; probably so constructed in the expectation that any attacking force would respect the place of worship. The early Scotch castles appear to date with the time when the Bruces and Baliols left their English castles and occupied Scotch ones.

During the 14th and 15th centuries there existed a considerable affinity between the Ecclesiastical and Castellated architectural decorations, thus the hanging tracery of Rosslyn Chapel and the west front of Holyrood is found in the court-yards of Linlithgow Palace and Stirling Castle. The projecting turrets, so peculiar a feature in Scotch Castellated Architecture, are wonderfully constructed; many of them being infinitely more massive and weighty than the walls to which they are attached. This is the case at Kirkwall, where the Bishop's Palace is a fine ecclesiastical fortress residence. This edifice and the Abbey of Crossraguel are magnificent specimens. In fact, the latter is a fortified abbey, with all the requirements of a cathedral establishment.

Some of the old castles appear to have been elaborately painted in what has been called fresco; but, from the fact of the paint peeling off, it was evidently never incorporated with the plaster or wood. In their plans the castles varied considerably; and this must be attributed to the most natural of causes—the architects in those days invariably suiting their plan to the nature of the ground on which they were about to build. Caerlaverock Castle may be mentioned as one of the most singular in plan, being triangular with round towers at two of the angles, and at the third double towers with a gateway between them. This is the only fortress in Scotland retaining a moat; the portcullis room, too, is very complete. Inigo Jones is said to have imitated the plan in Longford House, Wilts, belonging to Lord Radnor. Fivie Castle is another, quite peculiar in plan, and its elevation one of the grandest in Scotland: the centre also is highly illustrative of the Scotch Castle of the 16th century. The construction of the staircase is well worthy of notice, with its steps 16 feet long.

After the general introduction of gunnery on a large scale, by means of which the reduction of any fortress by a regular investment became only a question of time, the Scotch prudently defended their buildings against attacks by small arms, the only means that flying parties of marauders could have at command. This system was of great importance in developing architecture, for it did not prevent the addition of ornament to the Castellated house. The decorated terminations of the massive walls in some of these buildings, form a highly picturesque and pleasing contrast. It was, however, upon the old walls of keep towers, that the turrets, windows, and roofs of the domestic character are raised; and this will account for the disappearance of many of the old castles. Glammis, Castle Fraser, and others, are striking instances of the extent to which the Turreted style prevailed through the kingdom; nearly all the old keeps receiving new tops, some of them being of a highly ornamental character.

In the early part of the 14th century was introduced another mixed style, in which the Ecclesiastical and Domestic Architecture were combined, as at Dunfermline, where the history of domestic architecture is carried back to the Norman time: for in the windows of the basement, the bold arches of Malcolm's palace surmount the windows of a later period. As the first to notice this, Mr. Billings recommended its being preserved jealously, as the only known specimen of Domestic Architecture in Scotland of the Norman period.

We now pass to the revival of the Italian styles, which, beginning about the year 1580, continued for a full century, producing numberless buildings in a style romantically picturesque, and which bear strong evidence of the architectural ability of that period. Indeed this may be called the flowery period of Scotch Architecture. The mansions may be divided into three classes of design:—1st, where the chimney-shafts, crow-steps, and open parapets appear in combination, as at Wintoun House, near Tranent; 2ndly, where a combination of turrets and square chimney-shafts exists, as at Newark; and 3rdly, where the chimneys become quite secondary, the main feature of design being high roofs with dormer windows, crow-steps and turrets. Here the court-yard of Heriot's Hospital may be cited as an example. Dalpersie, in Aberdeenshire, is the link between the castellated and domestic styles.

The Domestic Architecture of Scotland bears evidence of the great attention paid by the architects to details. Thus the window heads, and other ornaments of Heriot's work, are a complete school of design: for in that building, only one case of repetition occurs in the ornaments surmounting the windows. Indeed this edifice, as a colossal example of one date, is unequalled. Two sides of Linlithgow court-yard are of a corresponding style of architecture, the remaining two forming an interesting example of the Domestic Architecture of the 15th century. In Scotch houses the opposite sides generally present a striking contrast in style; this peculiarity is fully illustrated in an example at Newark-on-Clyde. On the river front of this building, the combination of turrets, jutting staircases, and square chimneys, is prominent: while on the court-yard side not a turret is to be seen, and the dormer window forms the main feature of the elevation. The old keep tower, to which these domestic buildings have been attached, alone enables one to recognise the fronts as belonging to the same building.

There is strong reason to believe that the original combination of jutting turrets and corbelled staircases is to be awarded to Scotland alone, in spite of what may be called foreign types. Their conical tops may possibly have arisen from the staircase or recesses called oratories, which frequently occur in street architecture of the Gothic period on the Continent, and of which there is a specimen or two also in the Cowgate, at Edinburgh. These recesses are invariably supported upon a column, whose capital is bracketed out to the required size; but the corbelled bases of the Scotch turrets belong to the early period of castellated architecture, the variety and quaintness of decoration in their windows and mouldings marking them unmistakeably as Scotch. The general picturesque appearance of the small round turrets so peculiar to Scotland, is much heightened by their contrast with the opposite forms of square massive chimney-shafts, as may be seen at Newark.

Whosoever formed the school of design which lasted during the whole of the 17th century, deserves the highest credit. Schaw, who rebuilt one of the western towers at Dunfermline, died in 1602; and although the mixture of Italian and Gothic did not predominate until the 17th century, yet many of the Aberdeenshire castles bear evidence of its advent towards the end of the 16th, and Schaw was most undoubtedly practising successfully at this time. The principal baronial buildings were built, however, after Schaw's death, and generally bear their own dates, about 1650.

An interesting fact, discovered by Mr. Billings, proves that Wintoun House, Moray House, the Great Hall at Glammis, and Craigievar Castle, are works of the same architects and builders: nearly all the plaster work of these are cut from the same moulds. As an excellent example of the architecture of the middle of the 17th century, when it became the fashion to introduce the Doric, Ionic, and Corinthian orders, surmounting one another, the body of Holyrood Palace may be cited. Although Inigo Jones has always had the credit of designing Heriot's Hospital, and his name been identified with Glammis and with one side of Linlithgow Palace, it is singular that his name never appears on the records of the building, such as contracts or bills giving minute particulars, which are still in existence. There is, however, such a strong affinity between many of that great master's works in London and some of the northern buildings, that in the absence of proof positive to the contrary, they may safely be attributed to his genius.

The elegance and variety of design in the ornamental portions of the buildings of this period must not be passed over in silence; they evince a bold and vigorous determination to accomplish something original, carrying art as far beyond the meagre Italian types as it was possible. Wintoun House may here be mentioned as standing pre-eminent in the quality of its work. The design and execution of all its detail is perfection of the style. The artistic window-heads, quite distinct from the Italian style; the elaborate geometric foliated ceilings, the chimneys and their stacks, are all equally admirable; presenting together, perhaps, the most impressive specimen of Scotch Domestic Architecture. It should be mentioned as being unique among Scotch houses in not possessing corbelled turrets. In Craigievar Castle, in Aberdeenshire, the ceilings throughout are very similar to those at Wintoun, but infinitely more varied among themselves; and even the furniture partakes of the architectural character of the building: it offers a fine example of its time (1620).

Having shown how prominent the details stood in most of the buildings mentioned, it must be observed that one of the great causes of success in the Domestic or Baronial Architecture of Scotland was the comprehensive study of situation, and the composition of designs to suit these. The jutting turrets, gables, broken forms of detached roofs and surmounting towers, and, in short, all the playfully-picturesque forms of Scotch architecture, essentially agree with its landscape, and the fitful forms of its ever-changing clouds; and is as completely in harmony with the country, as are the stately unbroken forms of Greek and Roman temples with the cloudless skies of the countries to which they belong.

After the relinquishment of regular fortification, the Scotch did not give up its external appearances, for stone cannon in hundreds of forms, as gurgoyles, water-spouts, and more often as mere ornaments, are to be seen upon the more modern castles. In some of the old castles the formidable looking port-holes are on inspection found incapable of being used for working cannon, from the narrow dimensions of the walled recesses behind, there being barely room to make use of a carbine. The picturesque gateway at Linlithgow may be instanced as an example, being almost a sham armament. This innate love for fighting, which the Scotch at all times possessed, induced them to carry out their emblems of strife beyond the buildings in which they secured themselves; even the flower gardens being made to partake of a military character, as at Stirling. After the reformation had shaken the foundations of ecclesiastical domination in Scotland, it was to castles and houses that the ability of the architects were turned; and here is the golden age of Scotland's building fame. In other countries, the invention of gunpowder put an end to Castellated Architecture. It is scarcely to be doubted, that architecture in Scotland would have become more interesting, but for well-defined causes; the divided power of the monarch and the great feudal lords, and, the still more disastrous one, the English interference beginning with Edward the First.

The variety of Triforia in Scotland forms a curious feature, differing from those of England in the varied dimensions of the columns, in which must be recognised a spirit of determination to produce new effects.

The profusion of niches, also, and their elaborate details, must be considered also as a distinct feature in Scotch architecture. Bishop Kennedy's Monument, at St. Andrew's, is one of the most elaborate examples of monumental art in the world.

With regard to the Arch in Scotland, it cannot, with the exception of a few instances, be considered, as in other countries, any index to the style or date of buildings. The circular arch, only used in Norman architecture elsewhere, was always in general use north of the Tweed. A doorway of a later date than 1400, in the High-street, Edinburgh, the western door and the tower windows of Haddington, the doorway inserted in the semi-Norman wall of Holyrood Chapel, are all cases in point; their details proving them to be of a date later than their first appearance would imply. All kind of arches are common to Scotland, excepting the four-centered, peculiar to the English perpendicular; the only approach to this style out of England is to be seen in the east end of Stirling Church. It is rather then to their foliated detail of capital, bases, and mouldings, that we must look for the type of the time in which Scotch buildings were erected, and by these means the difficulty of distinction ceases. This is a remarkable feature in the Scotch architecture, a tenacity of retaining forms of styles while detail was degenerated. Thus, in Fifeshire, Dairsie Church and Michael Kirk have all the main features of early decorated buildings, and at a distance would be mistaken as belonging to that style, but the detail is decidedly debased in character, and the date upon each confirms the style from 1620 to 1630.

In the same manner that Scotch *Architects* mingled styles, Scotch *Poetical* epitaph makers adopted mixed languages; thus—

Here lies the Laird of Lundie
Sic transit gloria mundi.

Hic jacet Johannes Spencis,
Qhua biggit this Kirk Yaird Dyke at his ain expences.

England undoubtedly adopted the classical styles more readily than Scotland, and when the orders of architecture once had a hold they retained it, and our own styles became a dead letter. Scotland, on the contrary—ever cautious—adopted the orders very charily, and it was not until a comparatively recent date (1660) that the three orders were seen surmounting one another in Holyrood Palace. It is to this position that the Scotch castles and houses owe much of their interest, for the architects of the time only adopted so much of the detail of Italian architecture as left the spirit of their buildings entirely Gothic.

A cordial vote of thanks was immediately passed to Mr. Billings, for his graphic sketch of the history of Scotch architecture, and for the brilliant drawings by which his remarks were illustrated.

Dec. 17.—Sydney Smirke, Esq., V.P., in the Chair.

"On the Manufacture of Glass, and its application to Architectural Purposes." By Professor Donaldson.

After a few observations on the original introduction into Great Britain of this useful material (for architectural purposes)—which appears to have taken place in the seventh century of the Christian era,—Mr. Donaldson proceeded to describe the different materials and their proportionate quantities as employed in making glass. He then gave a very elaborate description of the various processes connected with the manufacture of the several qualities known as flint or crystal, crown, sheet and German sheet, bottle or common green, and plate glass.—A number of drawings illustrative of each stage of the manufacture were exhibited.—Mr. Donaldson particularly alluded to the extensive use of the "rough plate glass" for roof lighting, either in the form of tiles or of "lunette domes;"—some of which were exhibited, being 5 ft. 6 in. in diameter, from the establishment of Messrs. Swinburne.—The Venetian plate, impressed with a diamond pattern, was also mentioned as a beautiful and useful article for transmitting the light without allowing objects to be seen through it.—The ventilating glass for windows, called the "patent perforated," is an admirable invention; the glass panes being perforated at regular intervals, and thus admitting air while transmitting the light. As an auxiliary to the sanitary improvement of dwellings it may prove valuable, and become generally used. In allusion to the colour acquired by plate glass on exposure to the atmosphere, Mr. Donaldson observed that some experiments by Mr. Faraday had proved the cause to be the presence of metallic oxides, which were thus influenced by the atmosphere, and imparted the blue and purple tinge so frequently observable in window panes. Some specimens of glass silvered by a new process patented by Mr. Thompson, of Berners-street, were exhibited, and a deposit of pure silver is obtained by aid of saccharine solutions. The expense of this process has been reduced within such limits as give every prospect of its adaptation to a multitude of useful and ornamental purposes. The effect of gold, bronze, steel, &c., is readily given by the application of this process to coloured glass.

A discussion arose from an objection raised by Mr. Tite as to the correctness of the term "plate" being applied to glass which was *blown*. The question is one on which much difference of opinion exists, but Mr. Swinburne contended that the term is extensively used in the trade.

Mr. C. H. Smith offered a few observations on the practicability of cutting large squares of plate glass by the aid of a plane-edge saw and very fine sand—which he had ascertained beyond a doubt during the last summer.

SOCIETY OF ARTS, LONDON.

Nov. 28 and *Dec.* 5, 1849.—Benjamin Rotch, Esq., V.P., in the Chair.

"*On the Cultivation and Manufacture of Sugar.*" By Mr. J. A. Leon.

The modern agricultural improvements, irrigation and subsoil drainage, are little known in most of the British colonies, and very few of the commonest agricultural implements have been introduced there. The chief alteration which has been adopted is the planting the canes at a greater distance from each other than formerly. The theory of clearing, planting, moulding, and cutting the cane in suitable season is understood, but seldom practised. It is erroneous to suppose that European labourers cannot endure the climate in the sugar-growing colonies, and European emigration ought to be encouraged. The first improvement in the West Indies should be the organisation of a new system better adapted for emancipated negroes. The planter of the present day cannot do better than lease his fields to a set of negroes, on condition of their planting for him three-fourths of the land with sugar-canes; so that the negroes will be dependent for support on the produce and its quality, and will not fail to cultivate the land in a proper manner; the owner of the estate erecting improved steam-machinery, giving up the cultivation of the land, and remaining a sugar-manufacturer. The ex-planter, in his new establishment, will then no longer require hired negroes, for the people of his manufactory being British emigrants, the colonial sugar will be produced by Creole growers and European manufacturers. Small West India proprietors should join their lands, so as to form a farm of 700 or 800 acres, to be cultivated as before mentioned, and erect thereon a central sugar manufactory capable of working the produce from 500 acres of sugar-canes, which will be, on an average, 1,000 tons of Muscovado sugar from 10,000 tons of canes. Thus they would farm in a small space, and manufacture with powerful machinery, in which consists the required agricultural improvements, and isolated estates might send their concentrated saccharine matter, or crude sugar, to a parochial central factory.

The cultivation of the sugar-cane requires more labour than other plants, and in that respect a cane-field may be compared to a garden, and, like it, requires constant care and attention.

The woody part of the ripe sugar-canes is generally consumed as fuel in the process of manufacturing sugar; other portions are used as seed, forage, and manure, the green leaves being given as food to cattle. It is found that 100 lb. of canes generally yield 50 lb. of juice; these 50 lb. of juice produce by the old process of manufacture 5 lb. of Muscovado sugar and 5 lb. of molasses scum; the remainder, 40 lb., is the quantity of water to be evaporated by the manufacturing process.

Nothing can surpass the slovenly, unscientific way in which sugar is made on those estates where the common process is in use: and in the whole British dominions only four sugar plantations have received complete steam-machinery. The author recommends steam, not only as a moving power, but also for heating and evaporating purposes, and refers to a Colonial Steam Generator, which he has invented, as answering every purpose that can be required; but this modern apparatus will be only beneficial when worked on a large scale.

In selecting the ground on which a manufactory is to be erected mainly depends its future success.

The essay then describes the various existing mills made use of in the manufacture of sugar, of which the chief defects are—

1. Overspeed in motion.
2. Mismanagement in feeding.
3. Inefficiency of the moving power.

The great price of coal, however, in the West Indies, being 2*l.* 18*s.* per ton (when used), renders the working of steam-power very expensive; however, the steam may be economised and employed in subsequent processes.

The essay proceeds to describe the Steam Defecator, and other apparatus employed in the manufacture of sugar, and the advantages peculiar to each.

A great improvement in sugar manipulations, even greater than the concentration *in vacuo*, is the application of Animal Charcoal for manufacturing and refining sugar. The discovery of revivification allowing the same carbon to be used again enables the refiner to produce the best quality of sugar from the raw material by a single operation: *and by improving* on the same principle of filtration, the colonial manufacturer will succeed in producing refined sugar direct from the cane, and thereby dispense with the secondary manipulation in Europe.

Concentrated cane-juice, containing more than 50 per cent. of saccharine matter, will be altered if boiled at a high temperature, or re-concentrated at a low one; but if boiled *in vacuo*, the saccharine liquid may be rapidly concentrated at even a low temperature. The author recommends the use of Clark's Condenser, in which the steam is distributed all at once, in 216 vertical pipes, radiating to a single collecting pipe, communicating with the air-pump,—and a double-evaporation apparatus constructed by himself, and operating,

1st. Without altering the saccharine matter, as well with a minimum as a maximum of water.

2nd. Without borrowing any water.

3rd. Without requiring active superintendence, and saving fuel to a large amount.

In building a sugar manufactory, the main flue of the steam generators should pass close to the curing-house wall before reaching the chimney,—cast-iron tubes lying across the flue, having one end in the curing-house, whilst the other receives the outside air, being heated from the caloric from the furnace, warms the inner air passing from the yard into the curing-house. Thus a hot-air apparatus is formed with great economy. The direct bleaching, *i. e.* the artificial mode for separating the liquid from the solid sugar, is done by sprinkling water on the sugar with a small instrument made for that purpose; and, according to the number of ablutions, this operation will produce crushed lumps, or stamped loaf-sugar.

The modern steam apparatus for manufacturing sugar with profit requires the fulfilment of several conditions:

During crop-time, continuous work night and day,—from whence three advantages arise:

1st. The cane-juice does not become sour, as when standing during the whole night in the heated apparatus.

2nd. Fuel is saved, because the fire has not to be re-lit.

3rd. Double work being done, the expenses of the machinery are reduced 50 per cent.

A better class of labourers must be procured, and work for the whole year round provided for them.

Mr. Leon is of opinion that nothing but such a total change can restore the British sugar colonies; and to prepare for this, two things are necessary:

1st. A thorough knowledge of the modern art of building, erecting, and working the improved apparatus.

2nd. Regular theoretical and practical information on sugar manipulation for the instruction of colonial factory managers, to be given in a London laboratory, furnished with the necessary utensils for working on a small scale. The sugar for experiment should be extracted from the beet-root,—the juice of which is nearly identical with that of the sugar-cane.

The essay was accompanied with numerous drawings and models, illustrative of the apparatus and processes referred to.

Dec. 12.—T. Webster, Esq., V.P., in the Chair.

"*On the Application of Electricity to the Arts and Sciences.*" By Mr. Highton.

The paper was illustrated by beautiful specimens of simple and compound deposits as applied to works of art; also specimens of electrotyping, as applied to the preservation of animals, insects, and plants. A beautiful electrotype cast from a daguerreotype plate was also exhibited. Mr. Highton then alluded to the application of electricity to the art of war; to the freezing of water; to the formation of hail; to the ventilation of coal-mines; and finished by showing, that from the fact of electricity differing from all other known forces of nature in its property of producing direct circular motion, it became a most valuable analytical test for ascertaining whether certain other forces were simple and direct, acting in one straight line, or the resultant of a combination of forces acting in various directions. The author concluded by applying this analytical test to the motions of the heavenly bodies.

Dec. 19.—T. UWINS, Esq., R.A., in the Chair.

Mr. HIGHTON read a short supplementary paper, "*On the Application of Electricity to the Arts and Sciences,*" when a long and interesting discussion took place, during which the various processes of electrotyping were described by Messrs. Highton, Newton, and Hunt.

A number of new specimens of electrotype were exhibited, among which was some iron tubing coated with a deposit of cadmium to prevent oxidation; also iron covered with a deposit of brass, hitherto deemed impossible—the brass being a deposit of copper and cadmium, instead of copper and zinc. The construction of chronometer balances, on which a deposit of copper on the steel remains instead of brass without fusion, and the temperature of the steel remains the same as that of the atmosphere, was also exhibited. The remaining specimens, which were of remarkable beauty, were supplied chiefly by Capt. Ibbetson, Mr. Elkington, Mr. Collis, and Mr. Ackermann; those of the last-named gentleman being from the royal manufactory at Berlin. The paper concluded with a further explanation of the philosophical part of the subject.

A paper, "*On an improved method of constructing Buildings whereby they are rendered Fire-proof, without increase of Cost,*" was read. The leading features of the proposed method are, the substitution of joists of wrought or cast iron for those of timber (generally used), and the employment of successive layers of incombustible materials, supported by these joists, and forming the finished floor or roof. The great principle of the method is the development of strength and firmness by the combination and consolidation of the whole of these materials into a compact mass. The model placed on the table illustrated the successive steps in the formation of the floors and roof; and the remainder of the building was explained by the diagrams exhibited.

INSTITUTION OF CIVIL ENGINEERS OF IRELAND.

Dec. 11, 1849.—Lt.-Col. HARRY D. JONES, R.E., President, in the Chair.

1. A paper was read by Mr. D. GIBBONS, describing "*The Effects produced by the Action of the Sea in recent gales, upon the Piers at Kingston Harbour; also at Newcastle, in the county Down.*"

The history of the injuries caused by the action of the sea to the works of these harbours involved the consideration of two very important principles connected with harbour engineering—viz., the most suitable transverse section for sea-walls and piers; and also the depth of water at which the force of a wave, in its onward motion, would cease to prove effective, when coming in contact with sea-walls. These two subjects had engaged the consideration of other scientific societies for a long period, and much practical information was elicited, both from the account of the injuries as detailed by Mr. Gibbons, and from the very interesting discussion which ensued, and in which many members joined.

The PRESIDENT brought before the Institution the subject of "*Dover Harbour,*" and elucidated his remarks by reference to a plan prepared for the purpose. He described the original state of the harbour, and the effects produced by the motion of a pebble beach along the coast, by which, after a severe gale of wind, the mouth of the harbour was liable to be completely blockaded. The President minutely detailed the state of the harbour, as he had observed it, when he made a visit of inspection some years back, for the purpose of reporting to government the precautionary means which he might consider advisable to recommend. He also described the works at present in progress of execution, and the effects which he observed when visiting Dover this autumn as having been produced on the coast, by the construction of the groynes and pier, which was in the course of building, to arrest the progress of the beach.

2. "*On Branch Railways.*" By Mr. CHARLES BOURNS, C.E.

I hope the general importance of this subject will be deemed a sufficient apology for its introduction to the notice of the Institution. It may be assumed as self-evident, that the desire for investing money in railway speculations has been over-wrought. It is manifest that this laudable desire has been crippled, and reduced to a state of exhaustion by undue excitement. In fact, it is undeniable that vast sums of money have been injudiciously expended on railways. First of all, it is notorious that many lines of railway have been projected, and some of them partly constructed, which, probably, will never pay even their working expenses. Then, in England, the competition between different companies has led to ruinous expense. We have all heard of the "battle," or more properly the war, "of the Gauges;" which has cost the Great Western and the London and North-Western Companies such large sums of money. To such injurious stimulation, and to the prodigal expense incurred in the construction of branches and extensions, to say nothing of duplicate lines, we may attribute the present depression and stagnation. Let us, then, take warning by the errors of others, and endeavour to profit by their experience. We have to a great extent as yet escaped most of these; the object of this paper is to point out a mode of avoiding one main one. It appears to me that a grand error has been committed in having neglected the maintenance of a due proportion between main trunks and branches. In many cases, direct railway communication cannot be accomplished by main lines, and short branches on the same scale as the main lines would not be remunerative, and could not be advantageously worked; and no adequate means of overcoming these difficulties having yet been generally adopted, considerable towns are still shut out from many of the advantages of the railway system. Fortunately, however, we do not require another George Stephenson to invent a system for us. We have but to look back, and return to, and modify an old one, which in our speed we have almost forgotten. I allude to the working of railways by horse-power, which mode appears to me to be well adapted to meet the requirements of branch lines generally.

A branch to connect a town, or not unfrequently two towns, with a main line, will seldom exceed twenty miles in length—frequently not more than ten miles. In such cases the difference in time between horses and locomotives would not be important; and the means (that is the number of horses) could be adapted to the amount of traffic; whereas, if locomotive power were employed, it would be necessary always to use the engine, although probably not more than one carriageful (say twenty or thirty passengers) could ever be expected by one train. Then the fire must be kept alight all day long. Appropriate carriages being constructed, one horse, on good gradients, could draw thirty or forty passengers at a rate of ten miles an hour; of course, where stiff gradients occurred, two or more horses should be employed.

But the expense of the construction of a line would be very considerably less for horse-power than for steam; because the speed and the weight of the train being comparatively small it could at any time be readily stopped; so that public roads might be crossed on the level, thus saving the heavy expense of road-bridges, and their consequent heavy cuttings and embankments. The cuttings and fillings being thus made very light, and a single line only formed in the first instance, a hint might frequently be taken from the contractors' propensity for running into side-cuttings; so that where the embankments were of any considerable length, they might be formed, principally of the stuff taken from the boundary ditches; and this being all barrow-work, would be done at a cheap rate, and would afford much manual labour.

As to the working of the traffic the power required to move one ton on a level, on a well-made railway, is estimated variously at from six to ten pounds; we may fairly take it at 9·33 lb. or $\frac{1}{240}$th of the load. An average horse's tractive power is estimated at 150 lb., at 2½ miles per hour for eight hours a day. Then dividing one-horse power—viz., 150 lb. by the power required to move one ton—viz., 9·33 lb., we find that one horse can draw sixteen tons, twenty miles in a day, on a level railway. But as gravity acts in direct proportion as the height of a plane is to its length, we find that in ascending a gradient of one in two hundred and forty, the power required is doubled; so that up that plane a horse could draw only one-half of what he could do on a level. But on descending the same portion of the line he would have little more to do than to keep out of the way of the carriages. On descending a sharper gradient than one in two hundred and forty the horses might ride on trucks, as the vehicles would run down by the force of gravity.

But it is not necessary to occupy the time of the Institution with these details. It may be stated, however, that locomotives not being employed, the greatest weight to be provided for would be a goods wagon, travelling at about five miles an hour, so that a much lighter rail might be used than is required on a main line. I may observe, that I have made estimates, at full prices, for the works that would be required by the parliamentary sections of three widely different branch lines in this country. For two of these the amount falls short of 2,000*l.* per mile. In the other case, where the works would unavoidably be heavy, it would not exceed 2,000 guineas per mile. But this amount does not include land or stations, or other contingencies. However, as the land would be much less injuriously severed than for main lines; as locomotives would not be used; and all desired crossings might be given, the amount of compensation for land would be materially lessened. Another thousand pounds, therefore, that is, 3,000*l.* per mile, may safely be stated as being amply sufficient money to make any branch line of railway in Ireland, including the payment for land and stations, and all necessary works.

AGRICULTURE AND ENGINEERING.*

ENGINEERING is an enterprising calling; and it had need be so, for one great field of employment—railway work—has been very much narrowed, and others must be found: until a return to common-sense on the part of the lawmakers, or a turn in the money market, again allows the prosecution of public works At the time when the great rush was made into the engineering profession, and faculties and schools of engineering were set up, it was pointed out how wide is the scope for the application of engineering knowledge, besides the special construction of public works or machinery. In our mines, our manufactories, and the great operations of hus-

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* "An Essay on the Present and Future Prospects of Farming." By William Thorold, M. Inst. C.E. London: Ridgway, 1849.

bandry, in these islands, and in our settlements abroad, it was well said there was room for many men of good training. This has been found to be so; and notwithstanding the stoppage of railway and other works, we believe there are now more engineers in permanent employment than there were five years ago.

Nevertheless, the field is still untilled; for in our mines, in our works, and in the country districts, there are not so many skilled men employed as there ought to be. This must be set down mostly to two causes—the first, that young men start with the notion of becoming resident engineers, assistant engineers, or engineers-in-chief, with very high pay; and next, and following from the first, that all their time is given to railways or machinery; and without thinking of what is wanted to be a good mine captain, manager of a factory, or country engineer. The truth is, we have too many of the silver-fork men. When there was a good start given to engineering by the railways, papas and mammas thought there was an opening to put in some of those idle young men who want the luxuries of life with as little hard work as may be. Papa was quite willing to give a thousand pounds premium to a first-rate engineer, or to pay two hundred a-year at an engineering college, if his son were to get an appointment of five hundred or eight hundred a-year. The class of people who put one son in the army, another at the bar, send one to India, and buy a living for a fourth, thought a new land of promise was opened to them,—but which has turned out a land of disappointment to many. The end is, that all are looking after one walk of the profession, leaving several others less promising, but more sure, quite unoccupied. If a young man will content himself to make, as in other professions, a small beginning, we believe that, with a little capital to help him, there is enough to be done.

The alterations in the corn laws have served more than anything to show the English the need of more scientific, and we may say more mechanical, farming. This is now very fairly acknowledged—but how is it to be done? Not by the farmers, for they are the worst taught, least teachable, and least knowing of the community. It can be done and will be done by the engineers, if the latter will bestir themselves. They have already got work under the Boards of Health and in the colonies; now they must strive to get work from the landowners.

Mr. William Thorold is a member of the Institution of Civil Engineers, but he was brought up as a Norfolk farmer; and in this strait of free trade he comes forward to help his former brethren, by showing them how much is to be done: and as the few leaves he has written are mostly of an engineering character, our readers will like to hear something of what he says. We will not trouble them with Mr. Thorold's politics, and we will not give any of our own; but to put our readers in mind how the industry of the country is neglected, and how the true end of government is lost sight of, by the factions who hold the reins of power, we will simply say that in these islands

The labour of Five Millions of people is wasted, and heavy poor-rates paid, although the country might be provided with railroads, canals, harbours, docks, piers, breakwaters, bridges, drainage, churches, and schools, and with a good house for every man, rich or poor.

Millions of acres of improvable land are left waste, because those who would improve it are not allowed to do so. Hundreds of thousands of acres of rich land might be recovered from the sea and rivers, but the government gives every hindrance.[*]

Manure sufficient to grow food for Five Millions of people is yearly wasted.

Speaking of the re-arrangement of farms, Mr. Thorold says—

It will then be practicable to arrange the several farms in a more contiguous and compact manner, and the buildings as near as possible being in the centre of the occupation, it will probably turn out that several fields cannot be brought into an occupation, being too far from the buildings. These can frequently be let off at a higher rent to tradesmen and others, as accommodation lands; or converted into small farms and let to deserving tenants, who by perseverance in well-doing, will ultimately become competitors for a larger one; or it may even appear more desirable to take the out-laying fields from several adjoining occupations to make an additional farm.

It can hardly be expected that this system can be carried to its fullest extent without an act of parliament being obtained to exchange lands by consent of the parties in possession, regardless of the tenure and condition under which lands may be then held. Nothing can be more easy than to take powers in that act to secure all-incumbrances, settlements, &c., upon the exchanged land that existed upon the original. Powers also might be taken to borrow a limited sum of money (as has been already done by the Drainage Act) to carry out the exchange and improvements inherent thereon.

In carrying out these arrangements, the landowner will do right to have farms of different sizes, according to the extent of his estate, in order, as has been before hinted, to keep up a wholesome emulation and materials for competition, when necessary; and it should be a principle universally acted upon, that upon any farm falling into the landowner's hands, the first offer of it should be given to the most deserving and suitable tenant, then in the occupancy of another farm upon the same estate.

The next sacrifice is with regard to the timber and hedges upon the re-arranged farms. It is an essential part of the new system of farming, that trees, excepting those around the homestead, and in the boundary and fences next public roads, should all be cleared off the land; and in like manner the hedges and ditches also, except those forming the common out-fall drain of the district. The old ditches used as master drains upon wet soils, will, of course, have to remain as pipe drains of larger diameter.

It is not intended to have permanent pastures, except in particular localities, where it is obviously most profitable from the advantage that can be obtained by the frequent application of liquid manure, so as to produce two or more crops of grass in the same season; in all other circumstances, it has long been known that great injury has been sustained by both landowner and tenant, in retaining old hide-bound upland pastures, and most kinds of meadow land—whereas by a constant succession of corn and green crops, more food for cattle can be produced with the addition of a crop of corn every alternate year.

In carrying out all these arrangements, the landowner and tenant must cordially co-operate, the first supplying the capital for all permanent improvements, and the tenant paying interest upon the amount. Great care and judgment should be exercised in the execution, and they should be constantly under efficient supervision, not from any want of good intentions, but to avoid the possibility of failure. The author is sorry to say his impression goes to show that tenants with matured judgment are the exception, and not the rule.

It must also be a consideration in the first instance, whether the tenant, from his previous habits of business, not only can, but also will carry out, both the new arrangement of his farm, but likewise apply himself to the best modes of cultivation, and the application of manures to the growth of green and corn crops alternately, according to the best examples, it is presumed, he will see around him; if there is no prospect of a tenant's fulfiling all these desiderata, there is no alternative but for him to leave the estate, for "Why cumbereth he the ground?"—Landowners having quite as much right in taking the means offered for their own defence, as a party would in defending an action at law.

It is also essential in carrying out this system, as before stated, that the farm-buildings should be as near the centre of the farm as possible, which, if it cannot be obtained by exchange, addition, or reduction, the buildings necessary for occupation should be removed or built anew. The old farm-house can remain as a residence, or be converted into cottages, as may be most convenient in the preliminary stage of proceeding, and as it will frequently happen that where cottages are wanted, it will be a question whether the old farm-houses that are now on the outside of the farm, and consequently badly situated for the farmers' occupation, will not be in the most proper position for cottages? It is also necessary that good hard roads should be made, so as to approach one side of every field in all weathers, and a drift road made from the buildings to the most frequented public road.

Mr. Thorold proceeds to describe his plan for farm buildings:—

It will be impossible in an essay of this kind, to give general directions as to what buildings will be required, for in some instances, the old buildings may be made available to the new system, by means of internal alterations, and in other cases many buildings will bear the expense of removal; but by way of filling up a blank, the author has prepared a design for new farm-buildings, which is appended herewith, and as an explanation of this design will tend in some degree to elucidate part of the new system, he will proceed with the description.

The object of this design is to convert all the straw, hay, and green crops into manure, and to retain or prevent the loss of such manure after it is obtained, in the most effectual and economical manner; it is applicable to any sized farm, by merely increasing or diminishing the feeding and storing departments; but in all cases it should be limited to farms not exceeding a convenient length or breadth from the homestall, on account of the expense of road making and carriage. Steam power is intended to be applied to thrashing, dressing, grinding, and bruising corn, steaming food, cutting hay and straw into chaff, pumping water and liquid manure, slicing turnips, breaking oil cake, sawing wood, raising manure from the house by an inclined plane, to load the carts instantly, and prevent the horses waiting for the same; and probably for the purpose of exhausting foul air from the feeding houses, to excite hunger in cattle, and thereby diminish the time of fatting. It is here necessary to inform our readers, that this last plan has been adopted in factories as a principle of ventilation, and the only objection to it has been, that it makes the work-people always hungry, the very thing of all

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[*] The Woods and Forests have lately claimed the land recovered by the Cork and Passage Railway in Cork Harbour, but without offering to pay the expense of its reclamation. It is not so long ago since they made the Corporation of Liverpool compound with them for £100,000, for land reclaimed at Birkenhead.—The recovery of 30,000 acres of land in Morecambe Bay was prevented by the Crown and Duchy of Lancaster claiming it, if recovered.

others, beneficial in grazing or fatting cattle. Provision should also be made for rendering the feeding houses perfectly dark for an hour or so after feeding time, in order that the cattle may take their rest. Cramming may thus be introduced into cattle feeding, as has long been practised with ortolans, poultry, &c.

For this purpose a portable steam-engine is preferred (with fixed barn machinery, &c.) on account of its being applicable to more than one set of buildings, which will render it less expensive, and also more adapted to meet the possible contingency of steam ploughing, and being sent to the factory to be repaired, thus avoiding the nuisance of having mechanics on their premises, or it can further be supplied by a travelling or club engine. There is the corn barn open at each end, with a railway running through it, upon which stacks are to be built upon staddle-frames running upon wheels, instead of standing as heretofore upon fixed piers or pedestals, and as many staddles are to be provided as the probable number of stacks. A stack is to be built on these staddle-frames, upon any part of the railway, and can be run into the barn at night, and remain there under cover until is thatched, which it is obvious can be done either in wet or dry weather. As soon as it is thatched, it is to be run through the barn, a sufficient distance out of the way, and another staddle-frame is to be brought empty from the cross line, and a stack built thereon as before. As soon as it is ascertained that the barn will contain the remainder of the crop, it can be filled in the usual way, and of course this last must be thrashed out first; afterwards the stacks on the staddles can be introduced into the barn, and thrashed by a like process. The length of railway will be limited by the locality and expense, but it must be of sufficient length to admit of two or more kinds of corn being stationed on either side, so that any particular stack can be thrashed when wanted, by running all those before out of the way; as it is intended to have the rails perfectly level, but little power will be required to do this. Hay stacks may also be stationed on close boarded staddles at one end of the line, and can afterwards be brought into the barn when they are required to feed the hay cutter, being thus under cover during the time it would otherwise be partially exposed to the weather.

THE WATER MONOPOLY AND THE SANITARY MOVEMENT.

The subject of the water monopoly is now attracting so much attention as to induce the *Times* to devote to it its valuable columns, and the following forms part of a series of excellent articles, evidently from a man of knowledge and ability:—

In the year 1580 Peter Morrys, a Dutchman, came to the Lord Mayor of London, and declared himself the inventor of a plan for making the Thames water, by its own force, flow upward to the tops of the highest houses in the city. The supply of water being at that time excessively scanty, and the population rapidly augmenting, permission was granted to this daring schemer to try his experiment at his own risk. He stipulated for a lease of the first arch on the north side of old London-bridge, which was granted to him for 500 years, at a nominal rent of 10*s.* per annum, and he proceeded forthwith to erect his machinery. He set to work with such vigour that, a few months afterwards, the inhabitants of that part of the town were astonished one day to see a column of water rising into the air, and thrown completely over the steeple of St. Magnus Church. The lord mayor and aldermen came down to witness this experiment, the like of which had never before been known in England. The pipes of elmwood laid along Thames-street, Fish-street-hill, and Gracechurch-street, with their valves to prevent the reflux of the up-forced water, and their small leaden branches ramifying to the houses on either side, came in for a full share of admiration; and it would be difficult to exaggerate the joy of the fortunate householders in that neighbourhood at finding the water, which they had been accustomed toilsomely to fetch from the Wall-brook hard by, or to draw up with bucket and windlass from wells, now gushing spontaneously into their abodes, and let in or shut off as required, by the mere turning of a stopcock. We gather from ancient records of William the Conqueror's time, that the London water-sources of that period were, the Thames on the south, the suburban fountains on the north, such as Clerk's-well, Holy-well, Clement's-well, &c.; and in the heart of the city several brooks and bourns which rose from those fountains and ran southward to the Thames—the Wall-brook, for instance, the Long-bourn, the Old-bourn, and the Rivulet of the Wells; to which springs and streams the Londoners then resorted after the fashion of simple villagers, with pail and pitcher for their supplies.

The artificial conduit system appears to have originated in London towards the middle of the 13th century. For, in 1235, when the encroachment of buildings and the heightening of the ground had spoiled or dried up these fountains and rivulets, causing a dearth of water, while the rapid growth of the population still further increased, we find the Lord Mayor and Commonalty, at the request of King Henry III., engaged in bringing fresh supplies to the city from the town of Tyburn by six-inch pipes of lead, and setting about the erection of a great stone cistern, lined with lead and handsomely castellated, for the public use, in Westcheap. This, the "Great Conduit," as it was called, was the first of its kind in London, and its tedious and expensive construction occupied 50 years. The pipes from this watercourse were subsequently extended eastward, to supply other cisterns which were established successively in Fleet-street, Aldermanbury, and at divers other points of the town. As the population outgrew these supplies, the springs of Highbury (1438), Paddington (1439), Hackney (1535), and Hampstead (1589), were successively laid under contribution, and brought in earthen pipes, "brick drains," or tubes of lead, to the several standards or conduits, as they were called, in Oldborne (Holborn), Eoldgate (Aldgate), Cripplegate, Bishopsgate, &c.

These particulars give some idea of the solicitude felt from the earliest times to secure a good water supply for the metropolis. And, if we picture the water-carriers, stooping at the river side, clustered round the public tank, or bearing away on head or shoulder their replenished tankards—wide-bottomed, narrow-mouthed vessels, hooped like a pail, and fitted with a cork or bung—we shall have a tolerably complete notion of the ancient London water service.

The conservancy customs of those early times are vividly pictured by Maitland, who describes the mayor and aldermen riding forth on horseback, with their ladies following in wagons, to take their annual survey of the conduits; after which they used to hunt the hare across the neighbouring fields; then dine with the chamberlain; after dinner go to hunting the fox; and after "great hallooing at his death, and blowing of hornes," ride back through London to the Mansion-house.

The invention of the lift-pump (in 1425) might have been expected, by facilitating the raising of water, to improve in some degree the semi-barbarous state of the city. But the pump shared the common fate of useful inventions, always slow,—and especially slow in those days—to win popular acceptance; and, moreover, the cost of setting up an engine, then reckoned so rare and intricate, operated as a further hindrance to its general introduction.

The success of his first water-wheel, which raised 216 gallons of water per minute, induced Morrys to apply for a lease of the second arch of the bridge, which was immediately granted by the corporation on the same prodigal terms as the first. Beneath this arch Morrys proceeded to erect a second set of pumps and cisterns, with another water-wheel, by which means, 1584, he more than doubled his first supply. Our enterprising Dutchman, however, did not remain long without competitors. Within ten years after Morrys set up his first wheel, one Bevis Bulmar erected a large horse engine at Broken Wharf, in the city, and raised water through leaden conduit-pipes for the supply of Cheapside, St. Paul's Churchyard, and the parts adjacent, as far westward as Fleet-street. Animal power had previously been employed by the corporation to pump water to a standard on Dowgate-hill; but this mode of pumping proved too costly to be compatible with moderate rates, and Bulmar, like several similar speculators on a smaller scale, was ultimately ousted by the powerful competitor who next appeared in the field.

This was no other than the famous Sir Hugh Myddelton, a London goldsmith, who, having enriched himself by fortunate mining speculations in Wales, was emboldened by foregone success to adventure on novel hazards. The project was, to cut a trench or watercourse large enough for the supply of all London to any suitable spring that might be found within a circuit of 20 or 30 miles round the city.

The conception, grand as it was, did not exceed the grievous necessities of the time. For, the water supplied by Morrys from the Thames, besides being limited in quantity, was often exceedingly turbid and foul; and the unspeakable squalor of the poor occasioned well-grounded apprehensions that the plague, in those days a frequent sojourner in London, would renew its dreaded visitation. Moved by such considerations, the corporation had already, towards the end of Elizabeth's reign, obtained power from parliament to cut a river for conveying water to the city from any part of Middlesex or Hertfordshire. This done, they had rested on their oars, with true corporate procrastination, for six or seven years,—till, suddenly, in 1603, the plague broke out, and raged with such virulence that in one week it carried off upwards of 1,000 persons in the metropolis. Thus fearfully admonished, the corporation sent surveyors to examine where water might be procured; and having, after much delay, fixed on the springs of Amwell and Chadwell in Hertfordshire, 20 miles north of London, as sufficiently copious and pure for their purpose, they obtained in 1606-7 a new act, authorising the conveyance of these waters by an aqueduct to the city. Then followed two more years of vacillating delay; and at length, in 1609, their courage failing them after all, they made over to Myddelton, at his instance, their power to construct the New River, together with any profit that might accrue from the enterprise.

Myddelton immediately set to work, and soon found that he had undertaken a very tough job. The undulations of the ground obliged our projector, for the even distribution of the fall, to give his channel a devious and meandering course, nearly doubling the crow-flight estimation of its length, and the computed cost of the work; so that by the time Myddelton had brought it to Enfield—just about half-way to London—his progress was stopped by exhaustion of funds. The corporation, to whom in his exigency Myddelton applied for assistance, met him with a direct refusal: and King James I., to whom he next applied, declined, with characteristic rapacity, to afford him aid except on condition that a moiety of the concern should be made over to him for his exclusive profit and emolument. To these hard terms Myddelton perforce acceded; and, resuming his operations with his wonted energy, finally completed the work in 1613, twelve months before the expiration of the term allotted by the corporation for its achievement.

Estimating on the most liberal scale, the cost of timber, lead, and bricks, for the raised troughs, the reservoirs, &c., and making ample allowance for contingencies, we shall scarcely arrive at a larger sum than 150,000*l.** as the probable total expenditure up to Michaelmas Day, 1613;—when the water first flowed into the New River head, 85 feet above the mid tide level of the Thames.

Myddelton was now overwhelmed with laudations. He, however, being a shrewd, practical man, with a clear eye for the main chance, proceeded to retrieve his fortune by dividing his moiety of the concern into 36 shares, of which he sold about half, so as to replace, in part at least, his adventured capital. He then, in conjunction with his new partners, set about laying down wooden pipes through the town for the distribution of the water, which he shortly after began supplying to the inhabitants at an annual charge of about 1*l.* 6*s.* 8*d.* per house. As several thousands sterling per annum must have been thus received from the outset, and nothing was divided for 20 years, we may suppose that the excess of receipts, after paying cost of maintenance and interest of loans, was applied in extending the pipes. In 1619 the concern was incorporated by royal charter as the New River Company, with Myddelton as its first governor. Myddelton, however, who mistrusted the notorious selfishness and rapacity of his royal associate, contrived, with great sagacity, to exclude him from any share in the management.

For nearly a century the New River Company had the metropolitan water trade almost entirely to themselves. Morrys, indeed, continued to pump up and sell the feculent water of the Thames; and two small works, one at Shadwell (1660), the other at York-buildings, Villiers-street, Strand (1691), were also set up in the same trade. But both these latter establishments were ultimately beaten by their stronger rivals; and the York-buildings Company, in particular, was broken up by the competition of the New River Company, who, having ruined them, took possession of their district, buying only such portions of the plant as suited their purpose, and leaving the rest, an uncompensated loss, on the ousted company's hands.

During the earlier part of their career the dividends of the water traders were kept down by the frequent fracture and constant leakage of their pipes. These, being of wood, were of so small a bore that eight or nine collateral trains were required where now one capacious main is laid. One-fourth of the whole water supply leaked through them, converting the ground of London into an artificial swamp; and the discovery of one broken pipe would often involve 20*l.* or 30*l.* worth of digging and search. Notwithstanding these difficulties, however, we find the New River shareholders receiving, in 1663, 15*l.* 3*s.* 3*d.* per share on 72 shares, on which probably (by the foregoing estimate) from 1,500*l.* to 2,000*l.* each had been subscribed. From this time the profits increased rapidly; and Myddelton, finding this very shrewdly proposed to the needy and prodigal Charles to buy back the shares which his royal predecessor had acquired. King Charles willingly gave up his 36 shares for an annuity of 500*l.* a year; being probably between ¾ and 1 per cent. on the capital which they represented. In 1680 each New River share is stated to have produced a net dividend of 145*l.*; so that, on the re-acquired Crown shares alone, the company at that period must have netted a balance of 4,720*l.* per annum clear profit. An unlucky mischance having destroyed the company's ancient records, we are left very much in the dark as to ther original outlay and gains. But the returns of their modern expenditure on pipes and machinery, if pared down to a reasonable valuation, show a total probable outlay of capital of from 500,000*l.* to 750,000*l.*, at the utmost; or from 7,000*l.* to 10,000*l.* for each of the shares which now nominally represent and sell for about double the mean of those two sums. Even of this capital, a large proportion has, in reality, been contributed in the shape of excessive water-rates by the public.

The public water-service was gradually let slip by the corporation of London during the 17th century; and, little by little, yielded up to chance and private speculation. Many of the conduits, for example, which were damaged or destroyed by the great fire in 1666, were left to their fate; the melted pipes remaining unrepaired, and the tank-houses in ruin or demolished; so that a writer of the time bewails the hard case of the poor tankard-bearers, whose trade the conflagration had destroyed, "making them like to perish by fire who were wont to live by water." In 1692 the Hampstead waters, with the reservoirs which a century before had been built, at the public cost, for their reception, were given up by the corporation to some private individuals who, having obtained a charter, formed the germ of the present Hampstead Water Company; and a few years later (1701), the corporation let out the "Maribone" water, and several other conduit waters, to one Soams, a speculative goldsmith, reserving only a proportion of the supply for the use of the prisons and compters.

It was in the same year that the family of Peter Morrys, after having struggled on for nearly a century against the New River Company, was obliged at length to give up the contest; and it was to the above-mentioned Soams that they sold off their lease and plant for 38,000*l.* Soams seems to have made a good bargain; for he resold the concern to a company for 150,000*l.* in 300 shares. To this company, with are cklessness now become habitual, the corporation granted three more arches of the bridge, on leases, like the former, equivalent to perpetuity; which leases the city was obliged to redeem at a heavy cost to the public, when it became necessary to pull down old London-bridge and to remove the water-wheels beneath it.

A few years later, London having in the meanwhile rapidly extended westward, the Chelsea Company was established (1723), to supply a large district which lay beyond the range of the New River Company's pipes.

Soon afterwards the populous district south of the Thames—in itself a great city—attracted the notice of the water speculators. In 1758, the germ of the present Southwark Company was set up; and in 1785 a few private individuals commenced, on a very humble scale, the now powerful and lucrative concern known as the Lambeth Waterworks.

These five companies, three on the north of the Thames, and two on the south, possessed, until about the year 1805, the whole water trade of the metropolis.* Each enjoyed an effective, though not a legal, monopoly in its own district; and of their profits some notion may be formed from the fact that the Lambeth Company, which started with a capital of only 5,920*l.*, in 32 shares of 185*l.* each, obtained water-rents of such amount as enabled them in 33 years to invest, out of profits, 130,000*l.* in the extension of their works, *besides* paying dividends of 50 to 100 per cent. and upwards on the subscribed capital.†

To this palmy condition of the water companies the introduction of steam power into the water service had not a little contributed. This improvement, which we have adopted as marking the fourth epoch of our London water-history, dates from 1782, when the Chelsea Company substituted one of Boulton and Watt's condensing engines for the tidal wheel which had previously worked their pumps. Five years afterwards (1787) the New River Company, who had before employed, first a windmill, and then a horse-engine, to impel the water through the upper levels of their district, also set up a steam-engine on Watt's condensing principle. Even the old London-bridge Company erected a steam-engine to aid their water-wheels at low tides; and the three southern companies likewise found it their interest to adopt the same rapid and economical means of pumping.‡

One invention involves another. The old wooden pipes, which required renewal every 14 or 15 years, and were always leaking at the joints, soon proved inadequate to sustain the increased pressure of the higher level to which the water was raised by means of the new steam pumps. Hence the gradual adoption about this period of iron pipes, which were laid down in place of the wooden ones as these latter successively wore out. In this metal mains of 3 feet diameter, it was found, could be easily cast; and the vast columns of water thus conveyed took up less space under the roadway, caused less leakage, and required less frequent repairs, than half the stream conveyed tin he clumsy hollow trunks before employed. Iron pipes have their inconveniences, no doubt; amongst which may be mentioned that they appear apter than wood to accumulate, in the form of adherent incrustations, the chalky deposit of the water; so that in 20 years a 5-inch pipe has been found reduced to a 3-inch capacity; and in 50 or 60 years it may probably become necessary to incur the cost of taking it up, in order to remove this obstruction. The tenacity of the newly-adopted material, however, being such as to withstand with ease a pressure of 300 feet of water, facilitated the introduction of a third great improvement—viz., the high service. This fell in, happily enough, at the beginning of the present century, with the gradual introduction of closets requiring elevated cisterns for their supply. To the companies it proved highly advantageous, as affording them a pretext for adding 50 per cent. to their rates.

In 1805, however, an unexpected storm broke in upon their prosperous career. A water mania, like our recent railway mania, began at that period to spring up; and on its sudden outbreak in 1810 the principle of competition, to which the legislature had all along looked for the protection of the public, was put upon its trial. Two powerful companies, which had been several years occupied in obtaining their acts and setting up their machinery, now took the field: one, the West Middlesex, attacking the old monopolists on their western flank; the other, the East London, invading their territory from the opposite quarter. A the same time a band of dashing Manchester speculators started the Grand Junction Company with a flaming prospectus; and boldly flung their pipes into the very thick of the tangled network, which now spread in every direction beneath the pavement of the hotly contested streets.

These Grand Junction men quite astonished the town by the magnificence of their promises. "Copious streams" of water derived, by the medium of the Grand Junction Canal, from the rivers Colne and Brent,—"always pure and fresh, because always coming in"—"high service, free of extra charge"—above all, "*unintermittent supply, so that customers may do without cisterns;*"—such were a few of the seductive allurements held out by these interlopers to tempt deserters from the enemy's camp.

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* A watercourse of the dimensions of the New River is, we are informed, at this moment in course of execution in Holland, at a charge of 2,500*l.* per mile; at which rate the cost of the New River (39 miles long) would be only 97,500*l.*

* We pass over as insignificant three or four minor establishments no longer in existence, such as the small works at West-Ham, Shadwell, Rotherhithe, Bank-End, and Hackney. We also leave out of the account the Hampstead Company, which supplies spring water from Hampstead-hill to part of Kentish and Camden towns; the Kent works, which supply water from the river Ravensbourne to part of Deptford, Woolwich, Greenwich, and Rotherhithe; and the Paddington springs, which belong to the Bishop of London's estate, and supply the inhabitants of the immediate vicinity.

† The aggregate dividends received by the Lambeth shareholders during 16 years ending 1833, amounted to 66,400*l.*, or eleven times the amount of their original subscription. Of these 16 years the 11 earliest also form part of the 33 years (ending 1828) during which the vast capitalisation of the revenue mentioned in the text took place.

‡ The old steam-engines of Savery and Newcomen, in which the cylinder itself was cooled at each stroke of the piston, had been tried so far back as the beginning of last century by the York-buildings Company.

Meanwhile the South London (or Vauxhall) Company was started (in 1805) on the other side of the river, with a view to wrest from its old rulers the watery dominion of the South. The war was not, however, carried on in a very royal sort; for, as the travelling mountebank drives six-in-hand through a country town to entice the gaping provincials to his booth, so these water jugglers went round the streets of London, throwing up rival *jets d'eaux* from their mains, to prove the alleged superiority of their engines, and to captivate the fancy of hesitating customers.

The New River Company, thus put upon its mettle, boldly took up the gauntlet. It erected new forcing engines, changed its remaining wooden pipes for iron, more than doubled its consumption of coals, reduced its charges, augmented its supplies, issued a contemptuous rejoinder to its adversaries, and, appealing as an "old servant" to the public for support, engaged in a war of extermination.

For seven years the battle raged incessantly. The combatants sought (and openly avowed it), not their own profit, but their rivals' ruin. Tenants were taken on almost any terms. Plumbers were bribed to tout, like omnibus cads, for custom. Such was the rage for mere numerical conquest, that a line of pipes would be often driven down a long street to serve one new customer at the end. Arrears remained uncollected, lest offence should be given and influence impaired. Capricious tenants amused themselves by changing from one main to another, as they might taste this or that tap of beer. The more credulous citizens, relying on the good faith of the "public servants" (as these once powerful water-lords now humbly call themselves), were simpletons enough, on the strength of their promises, to abandon their wells, to sell off their force-pumps, and to erect waterclosets or baths on the upper stories of their houses. In many streets there were three lines of water-pipes laid down, involving triple leakage, triple interest on capital, triple administrative charges, triple pumping and storage costs, and a triple army of turncocks—the whole affording a less effective supply than would have resulted from a single well ordered service. In this desperate struggle vast sums of money were sunk. The recently established companies worked at a ruinous loss; and such as kept up a show of prosperity were in fact, like the East London Company, paying dividends out of capital. The New River Company's dividends went down from 500*l.* to 23*l.* per share per annum. In the border-line districts, where the fiercest conflicts took place, the inhabitants sided with one or other of the contending parties. Some noted with delight the humbled tone of the old arbitrary monopolists, and heartily backed the invaders. Some quiet old stagers stuck to the ancient companies, and to the faces of familiar turncocks. These paid; but many shrewd fellows put off the obsequious collectors, and contrived to live water-rate free. Thus the honest, as usual, paid for the knaves; and the ultimate burden of all these squandered resources fell (also as usual) on society at large.

Such a state of things could not last; and in 1817, the great water companies coalesced against the public; and coolly portioned-out London between them. Their treatment, on this occasion, of the tenants so lately flattered and cajoled, will never be effaced from the public memory. Batches of customers were handed over by one water company to another, not merely without their consent, but without even the civility of a notice. Old tenants of the New River Company, who had taken their water for years, and been their thick and thin supporters through the battle, found themselves ungratefully turned over—without previous explanation—to drink the "puddle" supplied by the Grand Junction Company. The abated rates were immediately raised, not merely to the former amount, but to charges from 25 to 400 per cent. more than they had been before the competition. The solemnly promised high service was suppressed, or made the pretext for a heavy extra charge. Many people had to regret "selling their force-pumps as old lead," or fixing waterclosets on their upper floors on the faith of these treacherous contractors. Those who had fitted up their houses with pipes, in reliance on the guarantee of "*unintermitting pressure*" found themselves obliged, either to sacrifice the first outlay, or to expend on cisterns and their appendages further sums, varying from 10*l.* or 20*l.* up to 50*l.*, and even in many cases, 100*l.* When tenants, thus unhandsomely dealt by, expressed their indignation and demanded redress, they were "jocosely" reminded by smiling secretaries, that the competition was over, and that those who were dissatisfied with the companies' supplies were quite at liberty to set up pumps of their own.

Flesh and blood could not long endure such exasperating treatment. The murmurs of the public, after continuing to increase during three years, broke out at last in a storm of indignation; and in 1821 the first of a series of parliamentary investigations took place. The committee of the House of Commons which conducted this inquiry, addressed themselves chiefly to the financial branch of the subject. They called for returns, examined engineers and secretaries, as well as aggrieved tenants, and brought to ght innumerable instances of injustice. Amongst other examples of rbitrary conduct on the part of these monopolists, it came out that they would frequently refuse water to a whole street of new houses; declining, when applied to, to run a service-pipe along it, even though their main passed the end of the street. And thus builders, in order to avoid having their houses on hand tenantless, were constrained to lay down pipes at their own cost; and then come humbly, cap in hand, to the company, to beg a supply at the ordinary rates.

The inquiry ensued a report (dated 1821) which deprecated the irresponsibility of these companies, and recommended a legislative restriction of their rates. Acting on this hint, Mr. Michael Angelo Taylor brought in his well known bill to restrict the water companies from increasing their rates to more than 25 per cent. beyond the rates of 1810. This bill passed the House of Commons, but was lost in a committee of the House of Lords by a majority of one. In the meantime the public attention had taken another direction; and the companies, finding the storm passed by, became bolder and more arbitrary than ever.

During this period the memorable bubble-fever of 1824-5 took place; and, as on a more recent occasion, the "earth had bubbles," so at that time had also the water,—in the shape of various brilliant schemes for bringing rivers to London by mighty aqueducts, and stupendous tunnels.

Suddenly, however, in 1827, a pamphlet appeared which threw the whole town into a state of consternation. This pamplet, which was called the *Dolphin*, originated, as its author declared, in the deathbed repentance of one Robson, a director of the Grand Junction Company; who, to use his own expression, "feared God would never forgive him" for having been party to the wronging of 7,000 families by the false promise of good water, and the cruel service of poisonous filth; and who, shortly before his death, to ease his conscience, divulged the enormities in which he had taken part to Mr. Wright (the pamphleteer), with an earnest request that he would by every means in his power seek legislative reparation of the fearful wrong inflicted on the public. This strangely originated document disclosed the secret abominations of the water trade; especially dwelling on the fact, that the Grand Junction "Dolphin" or suction pipe, lay exactly opposite the great Ranelagh sewer, *and only three yards from its mouth at low water!* The tract was eagerly bought up, and caused an excitement so intense that subscriptions amounting to upwards of 300*l.* were readily entered into for promoting its circulation. A public meeting was convened under the auspices of Sir F. Burdett, and all classes of society, from the highest peers of the realm down to the humblest shopkeepers, eagerly attended it. In the next session (1828) a scientific commission was accordingly appointed to institute the requisite investigations.

The facts elicited in the course of this inquiry were perfectly astounding. The New River Company, which was the first examined, was driven to admit that its principal reservoir had not been cleaned for 100 years; and that, when at last the water was run off, *eight feet of mud were found at the bottom!* It appeared that their pretended spring water was eked out by supplies, not merely from the river Lea, polluted by the sewage of Hertford, but also, to the extent of 300,000 hogsheads and upwards annually, from the Thames, between the mouths of the Fleet-ditch and the great Walbrook-sewer. To crown all, it came out that *Myddleton's aqueduct itself* had, by the neglect of the company for 200 years past, degenerated into a "common ditch," receiving the surface waters of the manured fields and the sewage of the populous villages through which it passed—an abomination which, having become a "vested interest," continues, we believe, to this day, in spite of the company's tardy and ineffectual remonstrance. It was further alleged that in consequence of their exorbitant charges for water, road-trustees had been driven to employ sewer-water for watering the streets! One witness stated that on being remonstrated with for leaving their water-plugs uncovered, so that ponies and donkies put their legs in the holes and were maimed, the company's officers declined to abate the nuisance, declaring it "cheaper to pay for the breaking of a donkey's leg now and then, than to incur the cost of putting covers to the plugs."

Finally, after weighing all the evidence, the commissioners produced a very able report, recognizing the insalubrity of the existing supplies, and the necessity of seeking purer sources.

In accordance with these recommendations, and at the instance and cost of Sir F. Burdett, the Lords of the Treasury shortly afterwards directed Mr. Telford, the engineer, to survey the country round London, with a view to discover the springs and streams most available for the supply of London, and to report on the means of conveying their waters to the metropolis. These researches having been set on foot, the public excitement again died away; and another six years' lull ensued.

The damaging disclosures which had resulted from the parliamentary inquiry of 1828, and the strongly expressed dissatisfaction of the public, at length aroused the fears of the water companies; who at this period appear to have been seriously alarmed as to the permanence of their misused privileges.

Accordingly, in 1829, the Chelsea Company began to send out filtered water; and in the following year the New River Company formed two settling reservoirs near Stoke Newington, with a view to purify by subsidence their drain-infected stream.

These improvements, though their empirical adoption under the influence of the "pressure from without" reflects small credit on the water monopolists, were, nevertheless, a very real and important step in advance. They were regarded by their introducers (and even by the parliamentary commissioners of 1828) as merely *mechanical* contrivances for the removal of sediment; but, when properly understood and practised, they are, as we shall hereafter have occasion to show, in a great measure *chymical* processes; and the date of their adoption opens an entirely new epoch of our metropolitan water-history. This, the fifth, or chymical period, is still in its infancy; and, though our present business is rather to record than to suggest improvements, we may perhaps venture, in defining the characters of this period, to indicate also the probable course of its future development. In the meantime we are bound to record, to the indelible disgrace of the London water companies, that filtration, to which they had only partially resorted in or about the year 1820, was in full operation many years previously at Manchester for the supply of pure water to the cotton manufacturers; of whose filters, in fact, those subsequently established on the banks of the Thames were but imitations at second-hand.

The example thus set was followed by several of the other companies; those, for instance, whose sources of water were the foulest and worst, began to think of extending their suction pipes to less objectionable quarters. Thus, the East London Company, which had previously pumped, at flood tide, from a point of the Lea so near its mouth, that the water obtained was in fact the turbid influx of the Thames itself, now brought their water by a canal three miles long from a place above the influence of the tide. The South London, following the example of the Chelsea, began to filter their drain-polluted water through beds of gravel and sand; and several other companies adopted, or discussed, similar partial measures of improvement. As for the Grand Junction directors—who had, from the first, been distinguished for the splendour of their promises—they gave out that they had in view a scheme of almost Roman grandeur. This dazzling proposal was to bring the water of the Colne to London by a canal twenty-five feet wide, with several tunnels and colossal aqueducts (of which latter, one was to be as high and three times as long as Blackfriars-bridge) and to undertake, by this means, the supply of water to the whole metropolis! This scheme was the revival of one originally proposed in 1719, during the South-Sea-bubble mania; and which, after being three times reproduced in the last century, and three times more in the present, by a series of more or less visionary projectors, was adopted by the Grand Junction Company. The directors introduced their bill into parliament; and were, of course, stopped by a resolution of the house to await the result of Mr. Telford's survey. It need hardly be added that the project was subsequently abandoned.

Suddenly, in the midst of these dilatory proceedings, the cholera morbus of 1832 broke out, and public attention in the metropolis was again drawn to the defective state of the water supply.

The Asiatic plague had not yet entirely subsided, when a new water committee was appointed to receive and consider Mr. Telford's scheme, and to examine generally the remedial branch of the question. As the two previous committees had reported respectively on the price, and on the quality of the water actually sold in London, so the business of the present committee was to investigate the relative feasibility of the various projects for improving, in both these respects, the future supply of the metropolis. This committee produced no report; but the minutes of evidence taken before them filled a large blue book, dated 1834.

It would be difficult to determine which of the various engineers examined cut the sorriest figure. Mr. Telford's assistant, Mr. Mills, charged his employer with filching his ideas; and the illustrious constructor of the Menai-bridge seems certainly, on this occasion, to have looked through his colleague's eyes somewhat more than he was willing to confess.

The plan was to form two aqueducts: one for the supply of London north of the Thames, the other for the service of the southern metropolitan districts. The northern aqueduct, 16 miles long, was to bring water from the Verulam, near Watford, at the rate of 30 cubic feet per second (about double the actual consumption of the northern districts); the southern aqueduct, 6 miles long, was to convey water from the Wandle, near Beddington, at the rate of 13 cubic feet per second—the actual consumption of the metropolis south of the Thames being then about 5½ cubic feet per second. The northern reservoir was to be on Primrose-hill, 146 feet above high water in the Thames; the southern one on Clapham-common, at a level of 80 feet above high water mark. The cost, including compensation to millers, was to be 785,065*l.* for the northern, and 391,875*l.* for the southern works. These works were to be executed at the public cost by government, who were to raise the money by loan, and to deliver the water into the pipes of the several companies, charging them interest on the capital expended, and leaving to them its retail distribution through the town.

Altogether the result of this third inquiry was negative. The need of improvement was clearer than ever, but the means of effecting it seemed proportionably more doubtful than before. The clashing opinions of the rival engineers showed on how empirical a basis our water system had grown up; and the bold pretensions of the chartered companies afforded a new proof how firmly corporate privileges, once conceded, take root; and how difficult it becomes, in the process of time, to correct the evil consequences of past legislative errors.

One point, however, was very clearly made out—viz., that notwithstanding the inertial resistance thus opposed by some companies to the public demand for progress, and the narrowness of the concessions which even the most liberal of them reluctantly made, the collective metropolitan water rents had increased since the last return in 1821 no less than 79,054*l.* a-year, an augmentation equivalent, at 5 per cent., to an expenditure in fixed capital by the companies of 1,581,000*l.* sterling; whereas 300,000*l.* only, or less than a fifth of the due proportion, had actually been laid out on extension of "plant" within the same period. Nor was this all. The added capital, thus virtually producing upwards of 26 per cent. per annum profit to the companies, had been mainly provided by the application of surplus revenues; or, in other words, had been extracted from the pockets of the public; against whom, nevertheless, this very outlay was now reckoned as a reason for maintaining the monopoly rates. 729,885*l.* was the vast total of capitalised plunder confessed to, in 1834, by six of the eight great companies,—the two others (the Southwark and the New River) setting down their plunder at zero.

The West Middlesex Company, in like manner, returned their "real capital embarked" as 568,045*l.*—a purely nominal and fictitious amount, eked out by the monstrous charge of 163,712*l.* as the interest which their plant *should* have produced, but *did* not, during the ruinous contest which they themselves set on foot. Wooden pipes, persisted in after iron ones had been invented; stone pipes, rashly adopted on insufficient trial, and burst by the first influx of the water; iron pipes screwed together in inconceivable defiance of the first principles of physics, so that they formed a solid rod, which, by its own contraction in the cold weather, tore itself asunder into fragments about 100 yards long—fragments which had to be patched together, and in that bungled condition remain to this day, a hidden monument of engineering incapacity; all these, and scores of equally costly errors, stand charged against the public as "capital embarked." In what other trade is such a mode of computation admitted? But if, adopting a truer standard, we compare their charges with the real value of the service rendered, as shown by the payment for which it *can* be, and *is*, profitably performed elsewhere, we shall find their rates something like 2,000 per cent. beyond the fair market price of the accommodation. Thus, at Tavistock, 4,000 inhabitants, residing in 650 houses, receive a constant and unlimited supply of water at an average charge of 2*s.* 5*d.* per house per annum; the average charge of the West Middlesex being 52*s.* 10*d.* per house per annum, the difference 2,200 per cent. And if 200 per cent. be thrown off to meet the objection that Tavistock is in respect of water service more favourably situated than London, and other such like pleas, there will still remain the monstrous excess of 2,000 per cent. as the measure of monopolist extortion!

No wonder that the public indignation remained unabated; that new water schemes abounded; and that Sir F. Burdett, who had already taken a prominent part in the free-water agitation, should again, in 1840, bring this question before a parliamentary committee—this time, however, of the House of Lords.

The Water-Committee of the Lords, in 1840, was specially charged to examine the project of a Mr. Paten, who enjoyed the patronage of Sir F. Burdett, and who proposed to bring water for the supply of London from the springs in a valley at the foot of the chalk hills near Bushey, by an aqueduct 12½ miles long, to a reservoir behind the Eyre Arms at St. John's-wood. This scheme virtually raised the important question how far the Artesian or deep-well system is available as a means of supplying the metropolis with water! Their lordships, however, separated without settling this or any other question, and without even making any report. But they printed the evidence taken before them in an entertaining blue book.

But the water companies, since their confederation in 1818, and after weathering the storms of 1828 and 1834, began to feel and exercise the independent powers of an *imperium in imperio*. In reply to the request of the Lords for returns of their pumping-costs, coal-consumption and the like, they one and all sent civilly-worded but firm and positive *refusals* of the required information.

Having thus, for the third time, passed through the ordeal of a parliamentary investigation without any legislative curtailment of their privileges, the water companies, in 1840, began again to regard their position as impregnable; and from that time to the present day they have accordingly continued to draw from the metropolitan public revenues, constantly augmenting with the annual extension of the town.

In the meantime, however, a new influence, unobserved by them, had been slowly growing up, and silently gathering strength—an influence which bids fair, at no distant period, to overthrow their confederated strength, and to emancipate London from their henceforth intolerable monopoly. This influence was the Sanitary movement.

In 1842, Mr. Chadwick condensed the information obtained as to the general health and condition of the people, in a report (the first on the Health of Towns) which created a profound sensation, and may be said to have given its first definite shape and powerful impulse to the rising sanitary party. Several thousand copies of this work were eagerly bought, besides 8,000 or 10,000 which were distributed to members of parliament and to the union officers. The horrible consequences of high-priced, scanty, and polluted water-supplies, detailed and *demonstrated* in this book, made a powerful impression on the public mind; and struck a deep though noiseless blow at the root of the metropolitan monopoly.

In 1843 this successful stroke was followed by another from the same hand, in the shape of a supplemental report on Intramural Sepulture—a work which extended and enforced the views of Mr. Walker on this subject; and which, amongst other things, proved the horrible pollution of the urban landsprings by the percolation of graveyard sanies.

These disclosures, though apparently tending to strengthen the water traders by discouraging reliance on the pump as a means o escaping their exorbitant charges, produced, in fact, a precisely opposite effect,—increasing the public abhorrence of the water monopoly by making its absolute and oppressive nature more undeniable.

In 1841 Sir Robert Peel (who had taken office three years previously), perceiving the strong current of public opinion that had set in towards sanitary reform, and fully recognising its importance himself, appointed a commission to inquire into the means and appliances, mechanical and administrative, proper for carrying into effect the sanitary principles that had been ennunciated, especially in respect to the drainage, paving, cleansing, and water supply of towns.

In 1846 the Health of Towns Commissioners produced their report and minutes of evidence on these questions—certainly one of the ablest and most comprehensive state papers that has ever issued from a government office.

Two years afterwards—in 1847—the government of Lord John Russell (who had in the meantime succeeded to office) appointed a commission to report on the means of carrying these principles into effect in the metropolis. This, the Metropolitan Sanitary Commission, which is still open, produced in the same year another admirable report.

In the following year—1848—the gloomy tidings reached us that the Asiatic cholera was rapidly travelling westward, and might be expected shortly to reach our shores. To meet this emergency, the sanitary party, ably represented on this occasion by Lord Morpeth (now Lord Carlisle), introduced and carried through, in spite of strong opposition from interested parties, the Public Health Act.

The prominent tendency of the new health act is to bring about, in every town of the kingdom, an economical *consolidation*, under one responsible public management, of those various services—drainage, paving, water supply, &c., on whose harmonious co-adaptation, hitherto unattainable, the sanitary well-being of the urban population depends.

The water companies, indeed, found means to procure the insertion of a special clause to protect their monopoly from the adverse operation of this act, by threatening its promoters, in the event of refusal, with a degree of opposition and delay, which, with a plague impending, it was in the highest degree important to avoid. The excepting clause, however, stands in such palpable contradiction to the general tenor of the act, that common sense cries out against its maintenance; and the discreditable tactics that procured its insertion, will, we have no doubt, by a just reaction, tend to hasten its inevitable repeal.

Scarcely had the sanitary idea thus acquired force of law, when the fierce outburst of pestilence through which we have just passed gave terrible proof of its necessity. At the eleventh hour, and after a stubborn resistance on the part of several local boards, the house-to-house inspection took place, and led to those dreadful disclosures which are still fresh in the public memory. Day after day men read with indignation and dismay of poor plague-stricken wretches crowded by scores round dribbling standcocks, and literally "*fighting for water.*" Instances still more horrible were reported by hundreds of squalid lanes and courts from which the monopolists *had entirely withheld supplies of water:* passing them by to lay their triple and quadruple rows of competing pipes in richer neighbourhoods promising more lucrative returns. The inspectors' reports, indeed, teemed with the complaints of destitute wretches, thus driven by joint-stock avarice to pump up and drink the waters of drain-infected wells;—of others, if possible, worse off, who had not even a pump to resort to, but begged their daily jugful from door to door;—and of a third set, most miserable of all, whom this last shift of penury had failed, so to use the official declaration of the city medical officer, they "actually lacked water for the ordinary purposes of ablution!"

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM NVOEMBER 22, TO DECEMBER 21, 1849.

Six Months allowed for Enrolment, unless otherwise expressed.

William Garnett Taylor, of Binton-house Hall, Westmoreland, gentleman, for improvements in lint, and in linting machines.—Sealed November 24, 1849.

George Callaway, of Putney, Surrey, station agent, and Robert Alee Pinkus, of the same place, engineer, for certain improvements in propelling ships and other vessels; also in apparatus for ploughing land.—November 24.

Charles Cowper, of Southampton-buildings, Chancery-lane, for certain improvements in piling, faggoting, and forging iron for plates, bars, shafts, axles, tyres, cannons, anchors, and other similar purposes.—November 24.

Joseph Barrans, of St. Paul's, Deptford, Kent, engineer, for improvments in axles and axle boxes of locomotive engines and other railway carriages.—November 24.

Ambroise Ador, of Paris, France, engineer, for improvements in producing light.—November 24.

Henry Lamplough, of Snow-hill, London, consulting chemist, for a new mode of supplying pure water to cities and towns.—November 24.

James Gaorge Hewey and James Newman, of Birmingham, for improvements in the manufacture of buttons, studs, and other dress fastenings and ornaments.—November 28.

Francis Tongue Rufford, of Prescot House, Worcester, fire-brick manufacturer, Isaac Marson, of Cradley, Worcester, and John Finch, of Pickard-street, City-road, Middlesex, manufacturer, for improvements in the manufacture of baths and wash-tubs, or wash vessels.—November 28.

Frank Clarke Hills, of Deptford, Kent, manufacturing chemist, for an improved mode of compressing peat for making fuel or gas; and of manufacturing gas; and of obtaining certain substances applicable to purifying the same.—November 28.

Charles Barlow, of Chancery-lane, London, gentleman, for improvements in the manufacture of a certain pigment. (A communication.)—November 29.

Louis Napoleon Le Gras, of Paris, France, civil engineer, for improvements in the separation and disinfection of fœcal matters, in the manufacture of manure, and in the apparatus employed therein.—November 30.

Walter Crum, of Thornliebank, Renfrew, Scotland, for certain improvements in the finishing of woven fabrics.—December 3.

Conrad Montgomery, of the Army and Navy Club, St. James's square, Middlesex, esq. for improvements in brewing, distilling, and rectifying.—December 3.

William Eccles, the elder, William Eccles, the younger, and Henry Eccles, of Blackburn, Lancaster, cotton spinners, for certain improvements in machinery or apparatus for preparing, spinning and weaving cotton and other fibrous substances.—December 3.

Joseph Paradis, of Lyons, France, merchant for improvements in the manufacture of elastic mattresses, cushions, and paddings, parts of which improvements are applicable to other purposes, where sudden or continuous pressure is required to be sustained or transmitted. (A communication.)—December 5.

George Buchanan, of Edinburgh, civil engineer, for improvements in cocks, valves, or stoppers; and in the use of flexible substances for regulating or stopping the passage of fluids; and also in making joints of tubes and pipes, or other vessels.—December 3.

Baron James Ulric Vaucher de Strubing, of Margaret-street, Cavendish-square, Middlesex, for improvements in the manufacture of axletree boxes for carriages, and of the bearings of the axles of railways; and in the making of an alloy of metal suitable for such and like purposes.—December 3.

George Edmund Donisthorpe, of Leeds, Yorkshire, manufacturer, for improvements in wheels of locomotive carriages.—December 3.

Peter Fairbairn, of Leeds, Yorkshire, machinist, and John Hetherington, of Manchester, for certain improvements in machinery for preparing and spinning cotton, flax, and other fibrous substances.—December 3.

Samuel Fisher, of Birmingham, engineer, for improvements in railway carriages, wheels, axles, buffer and draw springs, and hinges for railway carriage and other doors.—December 5

Edward Carter, of Merton Abbey, Surrey, machinist, for improvements in printing calico and other fabrics.—December 5.

Jonah Davies and George Davies, of the Albion Iron Foundry, Tipton, Staffordshire, engineers and iron founders, for improvements in engines worked by steam, air, water, and other fluids, and whether locomotive, marine, or stationary; and also in boilers, the principle of which improvements is likewise applicable to blowing air and pumping water—December 10.

Jean Baptiste Ecarnot, of France, for improvements in the manufacture of sulphuric, sulphurous, acetic, and oxalic acids, and nitrates.—December 10.

David Christie, of St. John's-place, Broughton, Salford, Lancaster, merchant, for improvements in machinery for preparing, assorting, straightening, tearing, teasing, doubling, twisting, braiding, and weaving, cotton, wool, and other fibrous substance. (A communication.)—December 10.

John Houghton Christie, of Craven-street, Strand, Esq., for an improved construction of wrought-iron wheels, and machinery for effecting the same. (A communication.)—December 10.

Thomas Grimsley, of Oxford, sculptor, for improvements in the manufacture of bricks and tiles.—December 10.

The Baron Louis Lo Presti, of Paris, in France, for improvements in hydraulic presses, which are, in whole or in part, applicable to pumps and other like machines.—December 10.

William Holt, of Preston-place, Bradford, organ builder, for certain improvements in the construction of pallets or valves of organ sound-boards or wind charts, the same being applicable to seraphines, colophous, harmonicums, harmoniums, and all other musical instruments, in which the tone is produced by the admission of wind, supplied by bellows or other machinery, to pipes, reeds, or springs, and played upon by a key-board, or key-boards, and also to various other purposes connected with all the above-named musical instruments.—December 10.

John Henry Jenkinson, of Salford, Lancaster, machine-maker, and Thomas Priestly, of Shuttleworth, Lancaster, manager, for certain improvements in machinery or apparatus to be used for preparing, spinning, and doubling cotton, wool, flax, silk, and similar fibrous materials.—December 12.

William Birkmyre, of Fulbech Cottage, Hampstead, chemist, for improvements in the manufacture and refining of sugar.—December 12.

Robert Harcourt, of Birmingham, manufacturer, for certain improvements in knobs, handles, and fastenings for doors and drawers; and in fastenings to be used in fastening window sashes, curtain and other rods, and for other like purposes.—December 15.

James Oldknow, of Lille, France, lace-manufacturer, for improvements in the manufacture of lace and other fabrics.—December 15.

Henry Roberts, of Connaught square, Hyde-park, Middlesex, gentleman, for improvements in the manufacture of bricks and tiles.—December 15.

George Wythes, of Reigate, Surrey, contractor for public works, for improvements in apparatus for receiving and retaining the rails of railways.—December 15.

Alfred Dalton, of West Bromwich, Staffordshire, ironfounder, for improvements in reverberatory and other furnaces.

Charles Cowper, of Southampton-buildings, Chancery-lane, for improvements in instruments for measuring, indicating, and regulating the pressure of air, steam, and other fluids, and in instruments for measuring, indicating, and regulating the temperature of the same, and in instruments for obtaining motive power from the same. (A communication.)—December 15.

Charles Lisars, of Paris France, engineer, for improvements in gas meters. (A communication.)—December 15.

Thomas Rock Shute, of Watford, Hertfordshire, silk throwster, for improvements in spinning, doubling, and throwing organsine silk.—December 16.

Timothy Hackworth, and John Wesley Hackworth, of the Soho Works, Shilden, Durham, engineers, for improvements in locomotive and other engines.—December 15.

Benjamin Fawcett, of Old Jewry, in the city of London, builder, for improvements in pigments, paints, and vehicles for painting.—December 15.

Isaac Lewis Pulvermacher, of Vienna, engineer, for improvements in galvanic batteries, in electric telegraphs, and in electro-magnetic and magneto-electro machines.—December 15.

Richard Hobson, of Leeds, doctor of medicine, for certain improvements in the manufacture of horse-shoes, and in apparatus for taking the measurement of horse-shoes or horse's hoofs.—December 15.

Edward Lyon Berthon, of Lareham, Southampton, clerk, Master of Arts, for certain improvements for ascertaining and indicating the course or way, velocity, trim, and draught of ships, and the rate of currents; also for discharging water from ships; and for taking altitudes and levels at sea and on land.—December 19.

James Smith, of Deanston, Perth, now residing in Glasgow, for certain improvements in treating the fleeces of sheep when on the animals.—December 19.

William Ackroyd, of Birkenshaw Mills, near Leeds, Yorkshire, for improvements in dressing and cleaning worsted, and worsted mixed with cotton and other fabrics, after they have been woven. (A communication.)—December 19.

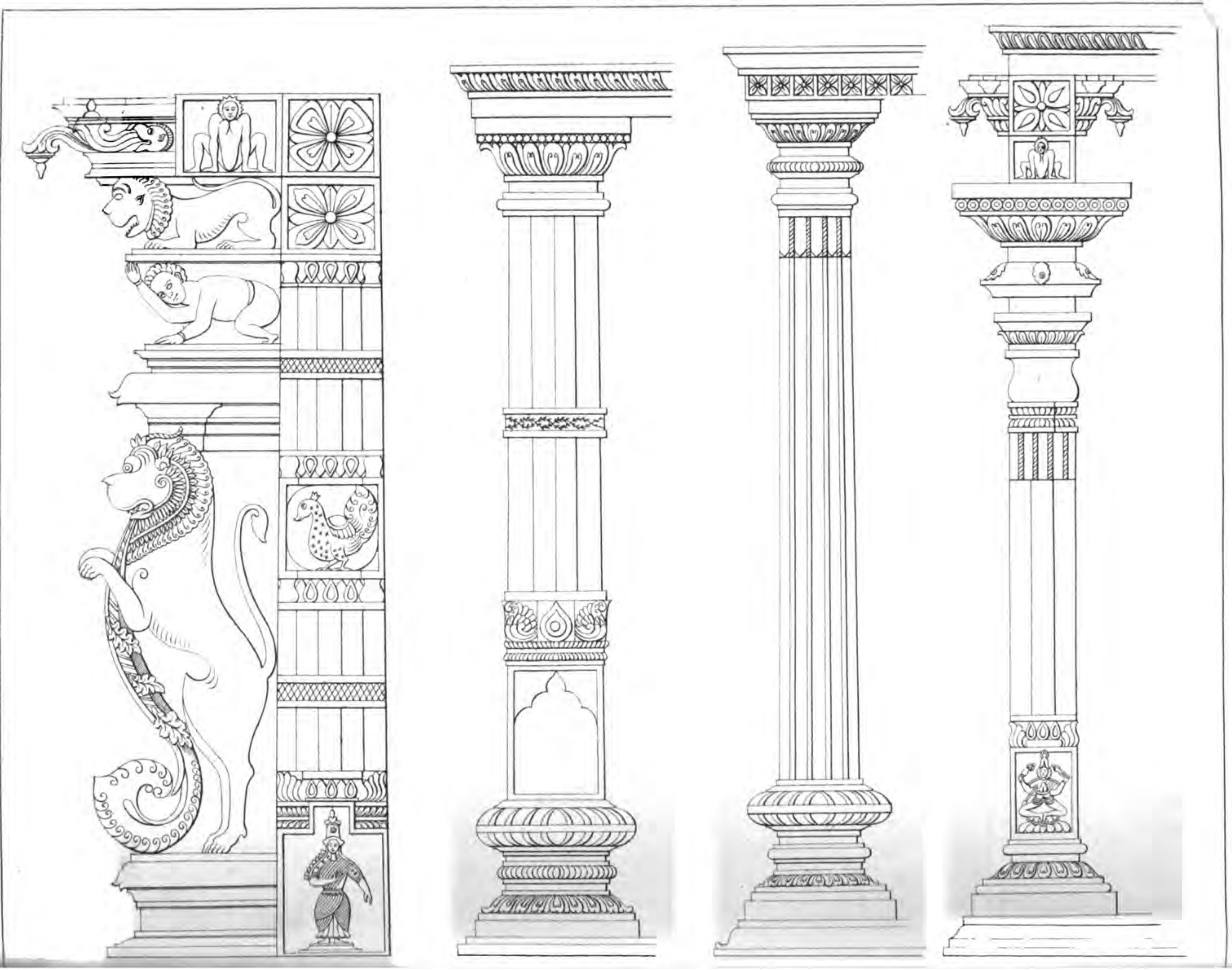
Warren De la Rue, of Bunhill-row, Middlesex, manufacturer, for improvements in the manufacture of envelopes.—December, 19.

Frederick Hale Thomson, of Berners-street, Oxford-street, and Edward Varnish, of Kensington, Middlesex, for improvements in the manufacture of ink-stands, mustard-pots, and other vessels of glass.—December 19.

Henry Fox Talbot, of Lacock Abbey, Wiltshire, esquire, and Thomas Augustine Malone, of Regent-street, Middlesex, photographer, for improvements in photography.—December 19.

Joseph Whitworth, of Manchester, engineer, for certain improvements in machinery or apparatus for cutting metals, and also improvements in machinery or apparatus applicable to agricultural or sanitary purposes.—December 19

Frederick George Spray, and George Wevell, of Hampstead-road, engineers, for an improved steam-engine; parts of the arrangements of which may be applied to apparatus for regulating, measuring, and registering the flow of liquids and gases.—December 21.



LECTURES ON ARCHITECTURE,

By Samuel Clegg, Jun., Esq.

Lecture II.—Phœnicia.—Assyria.—Persia.—India.

(*With an Engraving, Plate* III.)

In the Egyptian bas-reliefs we constantly meet with battle-pieces, where the enemy against whom the Egyptians are fighting are represented as on an equality with themselves, as regards civilisation and the art of war. These are the Hycsos, the inhabitants of Ludin, names of frequent occurrence on the Egyptian monuments; the former translated by Signor Rosellini as "strangers and wanderers," and the latter denoting the west and south of Asia. We have seen that these Hycsos were sufficiently powerful to overcome the Egyptians, and to keep possession of their country for upwards of a century. The principal nations included in Ludin must have been Phœnicia and Assyria; the former of which touched upon the Egyptian frontier at Pelusium.

We are told that the Phœnicians were an industrious people; the invention of letters is by some writers ascribed to them; and in commerce and navigation they far excelled the Egyptians, who, like the Indians, had a superstitious awe of the sea, and all who ventured thereon.

The Phœnician manufacturers were so celebrated in ancient times, that to whatever was elegant and tasteful in wearing apparel or domestic utensil, the epithet Sidonian was always applied. The most ancient author amongst the Gentiles, of whose writings any fragments have been handed down to us, was a Phœnician, by name Sanchoniatho. He claims for his native country the high honour of having given birth to our first parents; and, like all the old historians who were not particular in separating tradition from fact, evidently places implicit faith in the circumstances he relates. After enumerating several generations, Sanchoniatho says: "Then Hypsuranius inhabited Tyre; and he invented the making of huts of reeds and rushes, and of the papyrus." Then follow three more generations, after which he continues: "Of these were begotten two brothers, who discovered iron and the forging thereof. One of these, called Chrysor, who is the same with Hephœstus, exercised himself in words, and charms, and divinations; and he invented the hook, bait, and fishing line, and boats slightly built; and he was the first of all men that sailed; wherefore he was worshipped after his death as a god, and called Diamichius.* And it is said his brother invented the way of making walls of brick......Afterwards, from this generation were born two youths, one of whom was called Technites, the other Geïnus Autochthôn. These discovered the method of mingling stubble with the loam of bricks, and of drying them in the sun; and found out tiling." In the next generation, we are told, courts and fences for houses were invented, and caves or cellars. Then follow many other generations, and in their course the origin of almost all the useful arts is referred to the Phœnicians.

From the scanty information we possess relative to the architecture of the Phœnicians, we might be led to conclude that this bustling, trading, manufacturing people had not paid as much attention to the arts of architecture and sculpture as their more serious and learned neighbours, the Egyptians. But we are told in one place that the Tyrians were "the first to have advanced the science of architecture to any degree of perfection with regard to proportion, design, and variety of ornament;" and again, that among the Phœnicians not only the Doric order was known, but also a kind of rude Ionic, though with a different entablature. Is it not probable that in the grotto of Beni-Hassan (see engraving in Lecture I., *Egypt*, p. 8), we have a specimen of Phœnician architecture? These polygonal columns differ so widely from the native Egyptian (those in the form of a bundle of reeds), and though the form is again repeated in a second grotto at Beni-Hassan, and at Kalapsche, there is no reason why they may not have been equally imitations. The columns of the principal grotto at Beni-Hassan are pure, primitive Doric, and the dentel on the architrave has been found (as far as I have been able to ascertain) nowhere else in Egypt. We have no means of knowing in what style the more ancient buildings of This and Memphis may have been constructed; but as the sacred architecture was under the control of the priests, and as the most ancient was always held in the highest veneration, we have no reason to suppose that it differed from that of Karnac and Luxor, where no vestige of Doric appears, though the former temple was commenced about the same time as the grotto of Beni-Hassan (1600 B.C.) We learn from the inscription that Nahride Nevothph was a general—is it not probable that in some incursion into Phœnicia, he had seen and been struck with the Doric architecture, and had imitated it in his tomb? which, no doubt, for so eminent a man, had been prepared during his lifetime. It is strange that of a country so flourishing, and from which such numerous colonies were sent out, we should have no more exact information: even of its greatest daughter, Carthage, once the proud rival of Rome, there is now scarcely one stone left upon another, to tell what has been.

In the sacred writings we have an account of Hiram, king of Tyre, exchanging gifts with King Solomon: it seems they were both great builders. We find these monarchs mentioned, also, in a fragment of 'Dius' (Tyrian annals); but there, instead of being instructed in the style of King Hiram's building, we find those great potentates amusing themselves with setting each other riddles, and playing at forfeits. The anecdote runs thus: "Upon the death of Abibalus, his son, Hiromus (or Hiram), succeeded to the kingdom. He raised the eastern parts of the city, and enlarged it; and joined to it the temple of Jupiter Olympius, which stood before on an island, by filling up the intermediate space; and he adorned that temple with donations of gold. And he went up into Libanus (Lebanon), to cut timber for the construction of the temples......And it is said that Solomon, king of Jerusalem, sent enigmas to Hiromus, and desired others in return, with a proposal that whichsoever of the two was unable to solve them, should forfeit money to the other. Hiromus agreed to the proposal, but was unable to solve the enigmas, and paid a large sum as forfeit...... And it is said that one Abdemonus, a Tyrian, solved the enigmas, and proposed others which Solomon was not able to unriddle, for which he repaid the fine to Hiromus." It is worthy of remark, that mention is here made of a temple of Jupiter Olympius, in Tyre, about 1012 B.C.; the first authentic record of any temple erected in Greece being some centuries later. The inhabitants of Ægina, indeed, claim Æacus, son of Jupiter, as the founder of their temple of Jupiter Panhellenius; but it is needless to observe that such legends are worthy of little credit.

We now proceeed eastward to Assyria, whose sovereigns styled themselves "king of kings," as an assertion of their power and greatness. Until the present day, the Assyrians were even more enveloped in mystery than the Phœnicians; but by the talents and energies of Mr. Layard much has been revealed to us. All honour to him, and such as he is! There is a child's story, where a magician, by waving a wand before a mirror, brings over its magic surface the images of people and things belonging to long past ages,—nor is the story altogether a fable: it is our historians and antiquarians who are the true necromancers, bringing to our view scenes, and even the likenesses of those whose very existence had passed into the twilight of legendary times. We need not leave London to see Nimrod, "the mighty hunter," face to face; and to make ourselves as familiar with the eunuchs and ministers of the Assyrian court, as Holbein has made us with Henry VIII. and Cardinal Wolsey.

According to an ancient tradition, a civilised people possessed the country when Ninus founded the Assyrian empire; and having conquered this people, he attempted to destroy their works. We have no certain date of the reign of Ninus, but there is no reason to suppose the Assyrian empire less ancient than the Egyptian. Berossus, the Chaldean historian, a priest of Belus, who wrote in the time of Alexander the Great, describes Babylonia as a country which lay between the Tigris and Euphrates: "It abounded with wheat and barley......There were also palm trees, and apples and most kinds of fruits; fish, too, and birds......At Babylon there was (in these times) a great resort of people of various nations, who inhabited Chaldea, and lived without rule and order, like the beasts of the fields." He then goes on to describe how an animal, part man and part fish, came up from the Erythræum sea, which bordered upon Babylonia, and "taught them to construct houses, to found temples, to compile laws, and explained to them the principles of geometrical knowledge; he made them distinguish the seeds of the earth, and showed them how to collect fruits: in short, he instructed them in everything which could tend to soften manners, and humanise mankind."

The ruins of Babylon and Nineveh now present to the eye of the traveller, only vast mounds of earth; nor were there many more striking remains of the latter great city when Xenophon passed by with his "ten thousand," twenty-two centuries ago. To quote from Mr. Layard: "The graceful column, rising above the thick foliage of the myrtle, ilex, and oleander; the gradines of the amphitheatre, covering a gentle slope, and overlooking the dark blue waters of a

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* The name "Hephœstus" occurs in the list Manetho gives of kings in Egypt.

lake-like bay; the richly-carved cornice or capital, half hidden by the luxuriant herbage; are replaced by the stern, shapeless mound, rising like a hill from the scorched plain,—the fragments of pottery, and the stupendous mass of brickwork, occasionally laid bare by the winter rains......The scene around is worthy of the ruin he is contemplating; desolation meets desolation,—a feeling of awe succeeds to wonder; for there is nothing to relieve the mind, to lead to hope, or to tell of what has gone by." This description brings forcibly to mind the words of prophecy: "And he will stretch out his hand against the north, and destroy Assyria; and will make Nineveh a desolation, and dry like a wilderness. And flocks shall lie down in the midst of her, all the beasts of the nations; both the cormorant and the bittern shall lodge in the upper lintels of it; their voice shall sing in the windows; desolation shall be in the thresholds: for he shall uncover the cedar work. This is the rejoicing city that dwelt carelessly, that said in her heart, I am, and there is none beside me: how is she become a desolation, a place for beasts to lie down in!"

The architecture of the Assyrians offers a striking contrast to that of the Egyptians; nor, in taking the soil and situation into consideration, are we at a loss to account for the difference.

Nineveh, Babylon, Risen, and other great cities, had no doubt been founded on the banks of the Euphrates and Tigris for the sake of the easy transit afforded by the rivers, as well as for the great fertility caused by the abundant supply of water. Assyria occupied a vast plain, bounded on the north and east by the mountains of Armenia and Khurdistan; and on the west by the Arabian desert. Stone, of a serviceable kind, could only be brought from the distant mountains by an immense expenditure of time and labour, and was consequently only employed on statues, obelisks, &c.; and wood appears also to have been scarce, for Berossus, when enumerating palm, apple, and different kinds of fruit, makes no mention of timber trees; nor have the present inhabitants of the country any other than the palm and the poplar. Cedar was doubtless imported from Phœnicia, but must have been too valuable to use as a common building material. The Assyrians were, therefore, wholly confined to the use of brick, and the native coarse alabaster, which could only be used for cutting into slabs: this want of stone accounts for the total absence of fragments of columns, generally so abundant amongst ancient ruins. Strabo tells us they constructed columns of palm trees, round which, by way of ornament, they twisted bulrushes painted in various colours. These are probably the kind of columns represented on their sculptures; but of such frail materials all vestiges would naturally soon pass away.

The walls of Babylon have been a fertile source of exaggeration; but allowing for this, they must have been extraordinary works, and to the dwellers in the open plain they formed the only means of defence. According to Diodorus Siculus, there was sufficient space within the outer walls of Babylon not only for gardens and orchards, but to cultivate corn enough for the subsistence of the whole population, in case of siege: each city had also a citadel, and a ditch round the walls. The citadel was the holy place, where the palace-temple stood, where the treasures were kept, and where were preserved the records of the kingdom, carved in stone; it was also the place of refuge in time of danger. This sacred ground was elevated above the other buildings, both to give dignity to the palace-temple and strength to the citadel. In these plains, where no natural eminence was at hand, a regular platform of crude brick was constructed, 30 or 40 feet in height: the custom of building on elevated ground still exists, and many of the ancient mounds are occupied by a modern citadel. It was to defend this sacred inclosure that those huge walls were built, so often celebrated by ancient authors. Herodotus speaks of the walls of Babylon as 300 feet in height, and about 75 feet in thickness; and, according to Diodorus, the walls of Nineveh were 100 feet in height, and so broad that three chariots might be driven abreast upon them; 1500 towers were built at intervals along the walls, each 200 feet in height. Whether these dimensions be correct or not, it is certain that the fortification must have been of prodigious strength, as, in the reign of Sardanapalus, Nineveh was only subdued by the combined forces of the Persians and Babylonians, after a siege of nearly three years. At certain distances in the wall were the gates, either flanked by towers, or ornamented at the entrance by gigantic figures, such as the winged bull. The exterior of the wall was frequently cased with square slabs, most probably of the native alabaster, and was decorated with paintings. Ezekiel speaks of these paintings: "For when she saw men pourtrayed upon the walls, the images of the Chaldeans pourtrayed with vermilion; girded with girdles upon their loins, exceeding in dyed attire upon their heads." Diodorus says that on the outside of the principal palace of Babylon, built by Queen Semiramis, figures of men and animals were painted; and that the paint was laid on the bricks before they were placed in the furnace. Some enamelled bricks have been found at Nimroud, on which the colours appear to have been thickly laid in a liquid state, and afterwards baked in.

Of the architecture of the palaces of Babylon we have no account; but we may suppose it to have resembled the style of those structures discovered by Mr. Layard. Strabo has left us an account of the temple of Belus; by whose description it would seem to have been a pyramidal tower, of eight stories, with a winding staircase on the outside from the base to the summit, the highest story containing an observatory, fitted up for astronomical purposes. We are told also of quays, of beautiful workmanship, along the banks of the river; and of a bridge built by Semiramis over the narrowest part of the Euphrates, "founded with wonderful skill" in the bed of the river, supported by columns 12 feet apart. In order that the stones of which the bridge was composed should be firmly united, they were bound together by cramps of iron, run with lead; and to break the force of the water against the columns, sloping masses of masonry were built up against them; the roadway of the bridge was formed with beams of cedar and cypress, and was 30 feet in breadth. Dams were also constructed across the river, to secure a constant supply of water to the numerous canals, which spread over the country like network, and were known to have been the work of an ancient people in the time of Alexander the Great.

I fear the preceding descriptions must be taken as somewhat apocryphal, when we consider for how many centuries the mighty cities of Assyria have lain a heap of ruins; according to Mr. Layard, however, the Arabs state that when the river runs low, huge stones, united by cramps of iron, become visible, which they assert to have been the work of Nimroud.

It is not probable that any judgment can now be formed of the exterior architecture of Nineveh, so completely are the buildings buried in heaps of earth and rubbish; and it was only by laborious excavations that Mr. Layard gained an entrance into the interior of one of the great palaces. It is most probable they were flat-roofed, and did not rise above the height of one story. The walls of the chambers were constructed of sun-dried bricks, and were from 5 feet to 15 feet in thickness; from 9 feet to 12 feet of the height of this wall was panelled with slabs of the coarse alabaster or gypsum, with which the plains of Mesopotamia abound. The slabs were fixed in their place by wooden or metal cramps, dove-tailed into corresponding grooves in the adjoining slabs. After the wall was formed, the bas-reliefs and inscriptions were chiselled out: this is evident from the manner in which the sculptures and ornaments are continued from one slab to another. The wall above this alabaster panelling was formed either of richly-coloured baked bricks, or of sun-dried bricks covered with a coat of plaster, and variously decorated and painted. Here, several ornaments, now familiar to us through Greek art, appear to have originated—amongst others, the guilloche, and the device known as the Greek honeysuckle, or palmette. Assyrian art influenced that of Asia Minor, and so was transmitted to the Greeks, who knew so well how to harmonise and beautify every idea they borrowed, that what they produced from the crude conceptions of other nations was like the perfectly developed flower compared with the just opening bud. The roof in Assyrian buildings was formed of beams of wood; small beams, planks, or branches of palm were laid across them, and the whole plastered over on the outside. The disproportionate narrowness of the chambers would seem to forbid the idea of interior support by means of columns; one hall of the palace, though 160 feet in length, is only 35 feet in breadth. In the wider halls, it is probable that the centre was open to the air; indeed, it is to be presumed that all the chambers were lighted through an opening in the roof, unless artificially illuminated, for there are no traces of windows; and drains are found leading from each chamber, as if for the purpose of carrying off the rain that might have fallen from above. In the open halls it is conjectured that a projecting ledge may have been carried round the walls, sufficiently wide to afford shade and shelter,—and here, probably, the palm columns mentioned by Strabo were employed as supporters. The ceilings or soffits were divided into square compartments, decorated with painted flowers, or figures of animals, and surrounded by elegant borders and mouldings: in some instances, the compartments were inlaid with ivory, and the beams gilded.

The pavements were formed either of inscribed alabaster slabs, or baked bricks; at the threshold of each chamber, beneath the pavement, a small image was deposited, intended as a protection to the household. The entrance was guarded on either side by human-headed bulls, or sphinxes; the former were from 10 feet to 16 feet in height. The Assyrian sphinx was winged—thus adding the idea of ubiquity to that of physical and intellectual power; they occupied the same position here as in Egypt, and were in a like manner a type of the governing power.

Assyrian Sphinx.

The colours used by the Assyrians were the same as those employed in Egypt—copperas blue, red and yellow ochres, lamp-black, and calcined gypsum. There is no doubt that they were skilful workmen, and well acquainted with the use of metals. Of their skill in carving stone, we have only to examine the human head of the bull, and the small black obelisk, now in the British Museum, fully to satisfy ourselves.

I shall close this account of Assyria with another extract from Berossus, relating to Nebuchodonasor. He says: "Nebuchodonasor ordered the captives [Jews, Syrians, and Egyptians] to be distributed in colonies in the most proper places of Babylonia; and adorned the temple of Belus, and the other temples, in a sumptuous and pious manner, out of the spoils he had taken in this war. He also rebuilt the old city, and added another to it on the outside; and so far restored Babylon, that none who should besiege it afterwards might have it in their power to divert the river, so as to facilitate an entrance into it: and this he did by building three walls about the inner city, and three about the outer. Some of these walls he built of burnt brick and bitumen, and some of brick only......When he had thus admirably fortified the city with walls, and had magnificently adorned the gates, he added also a new palace to those in which his forefathers had dwelt; adjoining them, but exceeding them in height and in its great splendour. It would, perhaps, require too long a narration, if any one were to describe it: however, as prodigiously large and magnificent as it was, it was finished in fifteen days. In this palace he erected very high walls, supported by stone pillars; and by planting what was called a pensile paradise, and replenishing it with all sorts of trees, he rendered the prospect an exact resemblance of a mountainous country. This he did to please his queen, because she had been brought up in Medea, and was fond of a mountainous situation." This account places Nebuchodonasor before us in an amiable and poetical light, building up mimic mountains for his young Medean bride, to woo her into forgetfulness of her exile: for we can imagine her pining in the wide plains of Babylonia, being, as Berossus says, "fond of a mountainous situation."

Nineveh was destroyed by the united arms of Cyaxares, king of Persia, and Nabopolassar, king of Babylon, 606 B.C.; and Babylon shared the same fate in the following century, 538 B.C.

The ancient Persians do not appear to have been so learned or cultivated a people as the Egyptians and Assyrians, and evidently borrowed much of their architecture from their more civilised adversaries. When Cambyses conquered Egypt (524 B.C.), he not only carried away rich spoils and many works of art, but also skilful artificers; and it is evident that Cyaxares and Cyrus were not more scrupulous with regard to the Assyrians. We may form some idea of the appropriating propensities of the Persians, when we read that Ptolemy Euergetes, when he invaded the Persian dominions, brought back 2500 statues and other Egyptian works of art. According to the most ancient native authorities, Persia dates as a kingdom from a very remote period, and was governed by a race of kings called the Paishdadian, or distributors of justice; the most celebrated amongst these was the renowned Jemsheed, as familiar a name in ancient Persian history as that of Shah Abbas in more modern times. Persepolis is said to have been founded by this race of kings, and hence its native name is Tackt-i-Jemsheed, or the throne of Jemsheed. The only other ancient Persian cities of which any tradition or ruins exist, are Ecbatana (the ancient capital of Medea), Susa, and Pasargadœ, the royal city of Cyrus.

We have the same extravagant accounts of the walls of Persian as of the Assyrian cities. According to Herodotus, Ecbatana was surrounded by seven walls, each one rising above the other towards the citadel, and each painted a different colour; and the walls of Susa are described as above 120 stadia (15 miles) in circumference. After the kingdoms of Persia and Medea were united under Cyrus (550 B.C.), Ecbatana was the summer, and Susa the winter residence of the monarch, on account of the warmer climate of the latter city. The royal treasures were kept at Susa, and the palace is described as having been built of white marble, and its pillars covered with gold and precious stones; indeed, the Persians, though at first hardy and simple in their habits, appear soon after their union with the more luxurious Medes, to have imbibed that taste for gorgeous colouring, and elaborate ornament, that distinguishes the Persian architecture at the present day.

The remains of Persepolis, Ecbatana, and Pasargadœ, are sufficient to show that the same style of architecture prevailed throughout the Persian kingdom, and how nearly it resembles, in some respects, Egyptian architecture, and in others that of Assyria. Quintus Curtius speaks of Persepolis as "the glory of the East," and says that no other city existed that could be compared with it. Diodorus Siculus says, "A triple wall encircled the palace. ......The first wall was 16 coudes in height, defended by parapets, and flanked with towers; the second wall was in form like the first, but twice its elevation......The third wall was a square, and cut in the mountain, being 60 coudes in height. It was defended by palisadoes of copper, and had doors of the same, of 20 coudes high...... The first wall was to inspire awe, the second for strength, and the last for the defence of the palace." The principal ruin now remaining of Persepolis is called the Palace of Forty Pillars: the first object that attracts the eye is a large and high square platform, which is divided into three parts, each raised above the other. The stones of which this platform is constructed are of enormous size, some as much as 52 feet in length; and most of them from 30 to 40 feet in length, and from 4 feet to 6 feet in height; they are carefully hewn, and most of them polished; and so admirably fitted, that even after this lapse of time the joinings are almost imperceptible. The communication from one part of the platform to another is by means of a staircase, so wide that ten horses might ascend it abreast. The columns and fragments around would appear to have formed a vast portico; four pilasters remain, each 4 feet in thickness, and from 24 feet to 25 feet in height, probably forming the entrance, as on these are carved the human-headed bull, precisely similar to those found at Nineveh. Sir John Chardin speaks of thirteen columns as standing when he visited Persepolis, two hundred years ago, but several have since fallen: the columns are of white marble, with fluted shafts of slender proportions. The Persian capitals occupied a great proportion of the height of the column, and were of singular form—some being ornamented with rows of small volutes, something like the curls of an old-fashioned bag-wig, while others were surmounted by busts of the unicorn-bull: the bull being sacred to the worship of Mithra, it may be presumed that the columns with this form of capital were part of some religious structure. There are several niches yet standing, that no doubt formed part of the wall of the building: such niches are frequently seen in Persia at the present day, and are occupied by vases of flowers or plants. What makes these niches at Persepolis worthy of remark is, that they are finished with the bead-and-cavetto moulding, precisely similar to the doorways in Egypt. Another interesting part of the ruin is a terrace, on which are carved two ranges of bas-reliefs, representing a procession; the figures are a little less than 4 feet in height, and bear a remarkable resemblance to the Assyrian sculptures.—Persepolis was destroyed by Alexander the Great, after the defeat of Darius (331 B.C.)

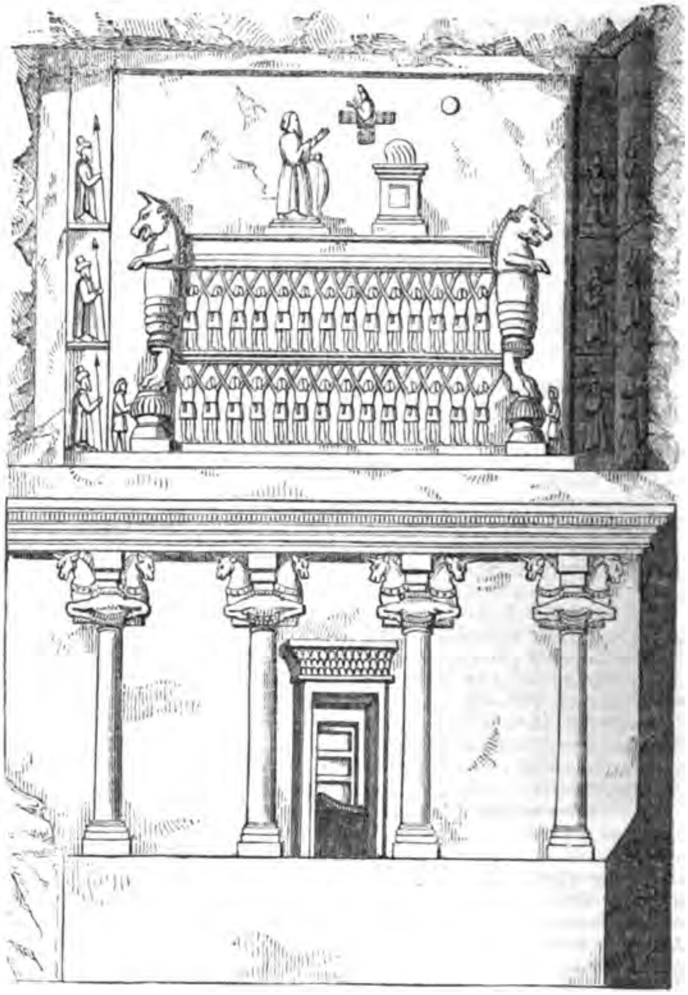
It would appear singular, at the first glance, that while Egypt and India abound in ruins of sacred buildings, a great and wealthy nation like Persia should possess so few: to account for this peculiarity, we must take into consideration the ancient faith of the people. Both Herodotus and Strabo assert that the Persians had neither temples, images, nor altars, but that they offered up their sacrifices on mountains or high places: this must be understood to allude to a very remote period, when the Persians were still worshippers of Mithra, the sun, as the type of the one supreme Deity. This simple form of faith continued until the time of Zerdusht, or Zoroaster, who introduced fire-worship. After his time, small shrines or tabernacles were built, for the preservation of the sacred flame; and altars were cut out of the rock, on which to offer sacrifice.

Two ancient altars remain near Nakshi Roustam; both standing on the same platform of rock, 12 or 14 feet from the ground; a flight of steps, hewn out of the solid, ascends from the south to the foot of them; each altar is a square of 4 ft. 6 in. gradually tapering to 3 feet; a heavy and rudely-shaped column runs up each corner, and rests on a square plinth; the capital is formed by a kind of torus, and a semicircular arch, in relief, extends from pillar to pillar. In the square top of the altar is a hollow, excavated to the depth of 8 inches, probably for the reception of the sacred fire. A fire tabernacle still exists in the same neighbourhood: this small building is much choked up with earth, but its present height is about 35 feet; it is built of marble, and curiously ornamented with projecting blocks along each course. The chamber is a square of twelve feet, the walls of which are completely blackened with smoke. When temples were first erected in Persia, they were still on high places, and open to the sky, the worship of Mithra forbidding the attempt to confine the Deity under a covered roof as impious.

In the reign of Darius Hystaspes, some alterations in religious forms were made, when the temples were roofed-in, the better to preserve the holy fire from the accidents of the weather; but the old belief in the superior sanctity of the canopy of the heavens never became extinct. The comparatively short period that elapsed between the reign of Darius Hystaspes (485 B.C.), and the annihilation of the Persian kingdom under Alexander the Great (331 B.C.), sufficiently accounts for the scanty remains which are found of these temples.

A few miles from Persepolis is the Nakshi Roustam, or mountain of sepulchres, showing by its extensive and numerous excavations that the adorers of the sacred fire were no less anxious for the preservation of their mortal remains than the worshippers of Osiris. This mountain is composed of a whitish marble, and rises almost perpendicularly to the height of about 900 feet. In the face of it numerous tombs have been cut, evidently of a date coeval with the prosperous days of the neighbouring city of Persepolis. The earliest and most elaborate sepulchres are the four highest in the rock; they are all similar—a description of one will therefore suffice. The façade of the tomb is divided into three compartments; the upper one is richly sculptured with figures in relief; beneath this is the entrance; four attached columns support an architrave, simply ornamented by dentils near its upper ledge. The bases of the columns consist of a torus and plinth, projecting 1 ft. 6 in. from the face of the tomb. The capitals are composed of the head, breast, and bent fore-legs of two unicorn-bulls, richly adorned with collars and trappings, united just behind the shoulders, leaving a cavity for the insertion of a block of stone to support the connecting architrave. Between the two centre columns is the doorway, having for its cornice the Egyptian bead-and-cavetto moulding; the greater part of the apparent door is only panelled, the entrance being confined to a square space of 4 ft. 6 in. high in the lower part of it. The third and lowest compartment has a smooth surface, terminating below in a deep hollow cut in the rock. The whole front is about 53 feet high. The chamber of the tomb is vaulted, and is 34 feet in length and 9 feet in height, the breadth of it being occupied by three arched recesses at its farthest extremity; each of these contains a trough-like cavity, hollowed out of the rock, 8 ft. 3 in. in length by 5 ft. in breadth, which no doubt contained the sarcophagus or the bodies; and they were covered by a stone of corresponding dimensions. The only mode of reaching these tombs is by means of a rope, the face of the rock affording no footing.

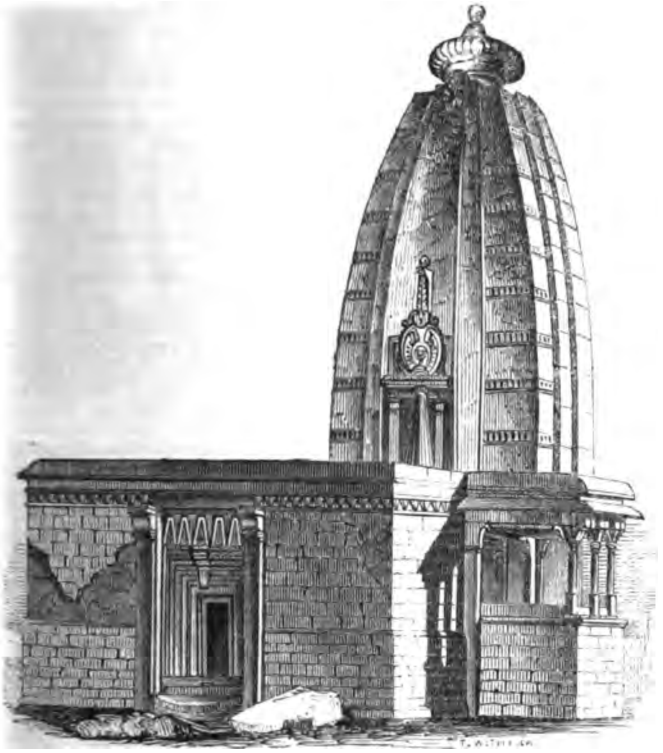
The tomb somewhat lower in the rock, on which is seen an inscription in the cuneiform character, is supposed to be that of Darius Hystaspes. It was on this spot, upwards of two thousand years ago, that the following catastrophe happened, as related by Ctesius:—An elaborately decorated tomb had been prepared by the orders of Darius Hystaspes, that his body might repose in due honour after death; but when intending to inspect it on its completion, he was forbidden to do so by the Chaldean soothsayers, who prophesied that some fearful accident would follow such an attempt. Darius submitted; but some young princes of his family, more courageous or less superstitious, determined, in spite of warnings, to view the interior of the tomb. The officiating priests agreed to draw them up to the entrance; but while they were yet suspended in the air, several serpents suddenly appeared on the rock, and so startled the priests that they at once let go the rope, and the princes were dashed to pieces in the fall.



Nakshi Roustam.

The Mithratic worship, though apparently at some remote era extending over almost all the then known world, lost its simplicity, and gave place to idolatry much sooner in some countries than in others; thus, while in Persia it was retained for many centuries, in Egypt and India it was soon confounded amongst other creeds, though never wholly disappearing: in India, therefore, temples exist from as early a period as in Egypt. It has been a subject of frequent discussion, which country can lay claim to the greatest antiquity, and whether (some resemblance being found in the arts and architecture of the two countries) one was derived from the other, or whether both may be esteemed coeval and original. I incline to the latter opinion. It does not appear that any resemblance exists that may not be accounted for by similarity of climate, and a common Asiatic origin. The palm and lotus are represented in the ornaments of both countries, because the palm and lotus flourish on the banks and in the waters of the Ganges, as well as of the Nile. The same gigantic proportions were aspired to by all the nations of antiquity; and we are equally struck with the magnitude of the ruins at Persepolis and in Central America, as with the temples of Egypt and the pagodas of India.

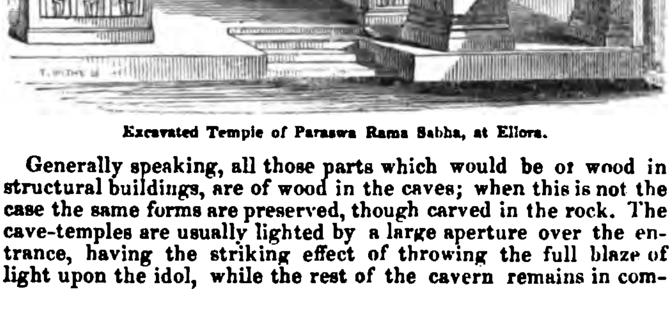
But if we notice points of resemblance, we must also notice striking marks of dissimilarity—for instance, the Egyptians always made ornament subservient to a meaning, and never allowed it to interfere with the grandeur of the outline: the Hindoos, on the contrary, sacrificed purity of outline to the elaborate ornament with which their pagodas are overloaded. In Egypt, the temples were of one simple angular form; and the peculiar worship to which they were dedicated, whether of Osiris, Amun, or Athor, was taught by the sculptures and hieroglyphics on the walls: in India, the whole *exterior* form of the temple was made to bear a certain significance; thus a corrupted form of Mithratic worship gave the circular dome, which in the interior was to represent the holy concave of the heavens, and was sprinkled with stars on an azure ground, or decorated with a sculptured zodiac; other pagodas took the more ancient pyramidal form, and some the two combined, showing a pyramid terminated by a cupola or globe; other Indian temples assumed, from the theology of their builders, the oval form of the mundane egg; and others, again, a square or cross, symbolical of the four elements and four cardinal points. The Egyptians, though avoiding all expression of human action or passion in their statues, never gave them those additional heads and limbs that deform Hindoo sculpture: while in some of the Indian bas-reliefs there is an idea of grouping and graceful attitude, not seen amongst the Egyptians.



Hindoo Temple at Deo, in Bahar.

The term "pagoda" applied to Indian and Chinese temples is derived from the Persian words *pout*, an idol, and *ghada*, a temple. The exterior of the pagodas are generally covered with figures of Indian deities or animals, sculptured with great spirit; and the lofty walls and ceiling of the interior are profusely adorned with rich painting and gilding: daylight is only admitted by the solitary entrance-door, but they are illuminated by ever-burning lamps suspended from the roof. The banks of the Ganges, Kistna, or other sacred rivers is, when possible, selected for the site of the great temples, in order that the worshippers may have the benefit of ablution in the holy stream: when the pagodas are at a distance from the river, a large quadrangular tank or reservoir is constructed in front, lined with freestone or marble, and having a flight of steps descending from the margin; many of the tanks are from 300 to 400 feet in breadth. The entrance to all the principal pagodas is formed by a portico with lofty columns, and ascended by a flight of stone steps, sometimes, as in that of Tripelli, to the number of one hundred. The gate is always fronting the east. The interior is divided into three parts, which may be compared to a centre and two side aisles; at the further end is the sanctuary, surrounded by a stone balustrade to keep off the populace. The pagoda of Santidus, in Guzzerat, is described by Tavernier as including three courts, paved with marble, and surrounded by porticoes supported by marble columns, and decorated with female figures sculptured in the same material. Into the inner court no one was allowed to enter without taking off his sandals. The ceilings and walls of the interior of the pagoda are adorned with mosaic work and variously coloured agates. The courts of the temple of Seringham, measured round the outer wall, are nearly four miles in circumference, and are entered through immense pyramidal gateways on each of the four sides. The pyramidal gateways leading to the magnificent pagoda of Chillambrun, on the coast of Coromandel, exceed 120 feet in height. The Choultry, or hall, in some cases is of enormous size, having 100 columns in length and 10 in width, or 1,000 columns in all: they are popularly called "halls of a thousand columns;" and this is usually literally true. When it is remembered that each of these columns is ornamentally carved from capital to base, that these carvings are usually all different in design, and that the material used is granite, it must be admitted that they are wonderful works.

The excavated temples of Hindostan have afforded a fertile theme for argument,—some authors taking their remote antiquity for granted, while others deny their existence beyond the invasion of the Saracens. Lieut. Fergusson upholds the latter opinion, principally on account of the frequent use of the arch. Now, the vault being a sacred form, a section of it may have been adopted in ancient times, and thus account for the semicircular arch so constantly found in these rock-cut temples; yet we must allow that when the ogee arch also appears, it affords conclusive evidence of their more recent date, as it is well known that this form was first employed by the followers of Mahomet. The remote antiquity of the excavations in India, as in Egypt, is objected to because most of them are imitations of structural models. Lieut. Fergusson says, that the Brahminical caves are always imitations, though those of the Buddhists are generally simple excavations. A mistake may have arisen from treating these rock-cut temples as if excavated at one period, when it is probable they were the work of successive centuries; for it is known that the Buddhists were the earliest cave-diggers, and that they made use of natural caverns, which they improved by art. The most simple excavations consist of a square cell with a porch; but frequently in the monastery caves, the verandha or porch opens into a square hall, three sides of which are occupied by cells—the hall being sometimes so large as to require the support of pillars; in a deep recess of it, facing the entrance, is placed a statue of Buddha: thus the cave is a place of worship as well as an abode for the priests. The Brahminical caves have generally a temple attached, which consists of an external porch, an internal gallery over the entrance, and a centre aisle twice the length of its breadth, having a vaulted roof, terminating in a semi-dome, under which stands a dagopa; a narrow aisle surrounds the whole interior, separated from the centre by a range of massive columns. This side aisle is generally flat-roofed, though sometimes in earlier examples covered by a semi-vault.



Excavated Temple of Paraswa Rama Sabha, at Ellora.

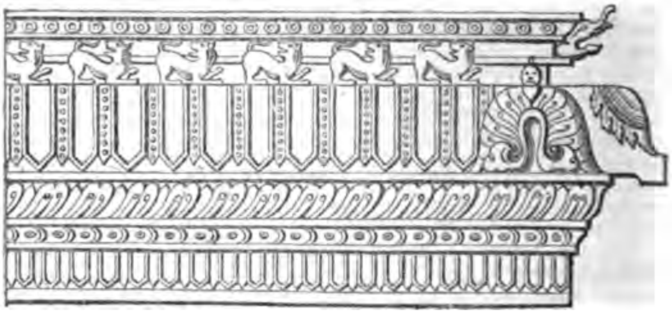
Generally speaking, all those parts which would be of wood in structural buildings, are of wood in the caves; when this is not the case the same forms are preserved, though carved in the rock. The cave-temples are usually lighted by a large aperture over the entrance, having the striking effect of throwing the full blaze of light upon the idol, while the rest of the cavern remains in comparative gloom. There are numerous groups of excavations throughout India, at Elephanta, Salsette, Ellora, and elsewhere. Lindschotten describes the caves of Salsette as so many separate ranges of apartments, rising in succession to four galleries or stories, containing as many as 300 chambers. The caves of Ellora, near Aurungabad, are amongst the most interesting—and the massive columns, with the cushion capital, the best specimens of this style. Some of the "ruths," or monolithic shrines, are cut out of isolated blocks of granite; others have the rock out of which they were cut so close round them, that they stand as it were in a pit, and are consequently imperfectly seen. Sometimes the excavated caves and monolithic shrines form a group, the latter being generally of a pyramidal form.

Oude is said to have been the first imperial city of Hindostan. Sir Wm. Jones says, "that if we may believe the Brahmins, it extended over a line of about 40 miles, and the present city of Lucknow was only a lodge for one of its gates." According to the 'Mahabbarat' (an Indian historical poem), Oude continued to be the chief city, until the erection of Canouge on the Ganges, about 1000 B.C.; at which time idolatry was introduced, idols set up, and Canouge adorned with numerous royal and sacred edifices. The regular empire of India may be said to have fallen with Callian Chund, who reigned over Hindostan about 170 B.C. Palibothra was the ancient city of which Strabo asserts that it was situated at the conflux of another river with the Ganges; that its figure was quadrangular; that in length it was 80 stadia, and 15 in breadth; and that it had a fortification of wood, with turrets for the archers to shoot from; and that it was surrounded by a vast ditch. Delhi was founded about 300 B. C. This city is described by the Persian historian Sherifeddin as consisting of three cities, Seiri, Gehampenah, and old Delhi or Inderput. Seiri and old Delhi were encircled by a wall; Gehampenah occupied the space between the two former, and was considerably larger than either; the walls by which it was fortified ran in parallel lines on each side, and connected Seiri and old Delhi. This threefold city spread over a vast extent of ground; according to Sheriffedin, it had thirty (others say fifty) gates: he informs us also that it was celebrated for a magnificent palace, erected by an ancient king of India, and adorned with one thousand marble columns. This noble city was destroyed by Timur, but rose again under his successors; when Agra was also founded, and strongly fortified.

The most wonderful amongst these monoliths or excavations is Kylas, or Paradise, near Aurungabad; this presents the appearance of an assemblage of temples, shrines, and columns, of various dimensions,—the whole loaded with minute and fanciful ornament that baffles description. The portico of one of the largest of the temples is supported by colossal elephants, and the front is entirely covered with figures of idols, animals, and arabesques, in infinite variety. For an idea of this marvellous excavation, I must refer the student to the beautiful and elaborate drawing of Lieut. Fergusson, in his work entitled, 'Illustrations of the Rock-cut Temples of India.'

The rules and principles of architecture, like those of most other sciences in India, have been locked up in the Sanscrit language; and every attempt made by the workmen to diffuse the knowledge they verbally received, was considered an encroachment upon the rights and privileges of the higher orders. Some interesting translations have, however, been given by Ram Raz, himself a Hindoo. The Sanscrit writings commence with various aphorisms, such as: "An architect should be conversant in all sciences; ever attentive to his avocations; of an unblemished character; generous, sincere, and devoid of enmity or jealousy......Woe to them who dwell in a house not built according to the proportions of symmetry. In building an edifice, therefore, let all its parts, from the basement to the roof, be duly considered." Then follow rules for choosing the ground: "The best sort of ground," says the Sanscrit author, "should abound with milky trees, full of fruits and flowers; its boundary should be of a quadrangular form, level and smooth, with a sloping declivity towards the east; producing a hard sound; with a stream running from left to right; of an agreeable odour; fertile; of an uniform colour; containing a great quantity of soil; producing water when dug to the height of a man's arm raised above his head; and situated in a climate of moderate temperature." The ground to be avoided is, "That which has the form of a circle; a semicircle; containing three, five, or six angles; resembling a trident, or a winnow; shaped like the hinder part of a fish, or the back of an elephant; or a turtle, or the face of a cow, and the like. Abounding with human skulls, stones, worms, ant-hills, bones, slimy earth, decayed woods, dilapidated walls, subterraneous pits, fragments of tiles, limestones, ashes, husks of corn; or exposed to the wafted effluvia of curds, oil, honey, dead bodies, fishes, &c. Such a spot should be avoided on every account." Then follow rules for ascertaining the solidity of the ground, and for various ceremonies, which so nearly resemble those practised at the founding of Rome, and consequently Etruscan, that they need not be mentioned here. The whole area of a town or village (according to the ancient authority), with the lands thereunto belonging, being divided into twenty equal parts: one is assigned for the occupation of the Brahmins, six or more for the other three classes, and the remainder for agriculture. Two or more tanks, or reservoirs, are to be built in every town. Private houses may consist of from one to nine stories; but this is to be determined according to the rank of the persons for whom they are built—the lower classes must on no account construct their houses of more than a single story or ground floor. In front of the houses, on each side of the door, should be erected a "védica," or raised seat, or pedestal.

The Indians employ seven orders of columns, classed according to the proportion between the diameter and the height. The second order, of seven diameters, may be compared with the Tuscan; the third, of eight diameters, with the Doric; the fourth, of nine diameters, with the Ionic; and the fifth, of ten diameters, with the Corinthian: but there is one order of six diameters, and two others from one to two diameters more lofty than the Corinthian. The first two orders of columns are always placed upon pedestals. The general rule with respect to the tapering of the shaft is, that the diameter at the base being divided into as many parts as the shaft is diameters high, the upper diameter is diminished by one of those parts. The higher the column, the less it tapers in proportion, because the apparent diminution of the column is greater according to its height. The plan of the Hindoo column admits of any form—circular, quadrangular, or octagonal; and the shaft is often richly adorned with sculptured ornaments. The intercolumniations have no fixed rule. The capitals do not mark the order, as in those of Greece and Rome, but, on the contrary, they may be varied at pleasure, though not without regard to the proportion of the column. The profile of the entablature changes little, but the pedestals and bases offer a great variety of outline and ornament. Occasionally, in temples and porticoes, figures of men or animals are carved in bold relief on the sides of pillars or pilasters. The pedestal is frequently employed over cornices, where the edifice consists of several stories, and also as a support for thrones and statues: in the latter situation, great skill has been displayed in their decoration,—nor would they disgrace any period of art in richness of ornament and beauty of proportion. The Engraving, Plate III., shows four of the Indian columns, and a fifth with a lion supporter.



Entablature.

The Hindoos make use of two sorts of cement, or "chunam;" in the interior of the country, it is prepared from a gravelly sort of limestone mixed with sand; and along the coast, from the shells washed out of the salt water marshes—the shell "chunam" is preferred—also mixed with sand; and is mixed with "jaggery-water," a solution of molasses or coarse sugar, the use of which seems to have prevailed from the earliest ages. There is another kind of chunam (not mentioned by Ram Raz), prepared from calcined shells, without any admixture of sand or other foreign matter, and used as plaster; it is tempered with as little water as possible, and well worked-up; when yet moist, it is rubbed, and is susceptible of a high polish.

I shall conclude this lecture with the description of an ancient Indian city, as given in the 'Ramayana':—"On the banks of the Saraya is a vast, fertile, and delightful country, called Cosálá, abounding in corn and wealth......In that country is a city, called

Ayódhya, greatly famed in this world, and built by Mann himself, the 'lord of men'......This great and prosperous city was twelve yojanas (nine miles) in length, and three yojanas in breadth, and stored with all conveniences. The streets and lanes were admirably disposed, and the high roads were well sprinkled with water. ......It was adorned with arched gateways, and beautiful ranges of shops; it was fortified with numerous defences and warlike machines, and inhabited by all sorts of skilful artists...... It was beautiful with gardens and groves of mango trees, and inclosed with high walls......It was surrounded by impassable ditches, and secured by fortifications difficult of assault by foreign kings...... It was ornamented with palaces of exquisite workmanship, lofty as mountains, and enriched with jewels; abounding with beautiful houses consisting of several stories; and it shone like Indra's Heaven......Its aspect had an enchanting effect; and the whole city was diversified with various colours, and decorated with regular avenues of sweet-scented trees......It was filled with buildings erected close to one another, and without intermediate voids; and situated on a smooth, level ground......This city truly surpassed any that was ever beheld on earth."

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ARCHITECTURE OF SOUTHERN INDIA.

On the Architecture of Southern India. By JAMES FERGUSSON, Esq., Architect.—(Paper read at the Royal Institute of British Architects, January 7th.)

Those who heard me on a former occasion may recollect that I pointed out, and strongly insisted on the fact, of India being occupied by two distinct and separate races: one of these aboriginal, occupying exclusively at the present day the southern extremity of the peninsula, and extending to and across the valley of the Ganges; but there only as an underlying stratum to a second race. These latter, commonly called the Indo-Germanic or Sanscrit race, came across the Indus from the north-west, and gradually displaced the aboriginal native tribes in the valleys of the Indus and Ganges (except to the extent above pointed out); in these countries they are, and, as far as our histories extend, they always were, the dominant classes. All we know of the literature or history of the country is owing to their superior energy and intellectual development.

The Southern or Tamul races never, apparently, had a literature of their own; most of their dialects are quite uncultivated, and so deficient are their literary records that we know almost nothing of their history or of their intellectual culture. Notwithstanding however this literary and historical poverty, the inhabitants of the south were far more daring and extensive builders than those of the north; and indeed I do not know of any region on the surface of the globe, that can boast of the same number of temples, covering so much ground, and showing such an infinity of labour bestowed on their details; and as such, they certainly deserve to be known and studied.

The principal buildings in the south of India are of course temples, as is the case in most countries, and is always the case in half civilised ones. In this region the temples consist principally of two parts; one of which, called the *Vimana*, is the temple proper—the other, or *Gopura*, is the gateway. There are besides, halls of various dimensions, and walls surrounding the various courts, which I will speak of afterwards. But to begin with the vimana—this consists in all instances of a square basement, of one or two stories in height, ornamented with pilasters, between which are niches containing statues of the gods; within the basement is a square or rather cubical apartment or cella, the sanctum of the temple, in which the principal image of the god is placed. This basement is always built of stone—in the extreme south, an old red sandstone; a little further north, of compact limestone; but over the greater part of the country of a fine close-grained granite. Above the basement rises a pyramidal building, composed of brickwork covered with the fine durable cement of the country, which retains its sharp edge even after the wear and tear of nearly a thousand years. This pyramid consists of one, two, three, four, or more stories, up to twelve or fourteen, according to the dimensions or importance of the building, and is always surmounted by a circular dome-like termination. Each story of the building is ornamented by alternate long and short miniature temples or shrines—alternate vimanas and gopuras in short—each smaller one with at least one image before it, the larger ones with three, or often with groups of a greater number of figures. These smaller shrines, however, though they relieve and vary the surface of the pyramid, are never so important as to break the general outline, which always retains that of a straight-lined pyramid.

The gopura is in every respect identical with the vimana, except that its plan instead of being an exact square is always oblong, generally in the ratio of three to two, so as to admit of its being pierced by the great doorway which always traverses its lesser diameter. The change in the form of the base also necessitates a change in that of the crowning member, which instead of being circular is elongated into a sort of wagon roof, difficult to describe, but easily understood from the drawings. In the mode of decorating it, either architecturally or with sculpture, it is identical with the vimana.

To the vimana is generally attached a porch (or *Mantapa*); frequently this is only a repetition of the basement of the temple, but with a low roof instead of the high pyramidal one of the temple; frequently, however, the porch is open and columnar; in small temples of merely two or four pillars supporting a flat roof, but frequently of thirty or forty pillars, arranged as shown in the diagrams, in a manner which displays the principal peculiarities of the style. Generally speaking the columns are square in plan, changing into octagons and circles, or figures with sixteen sides, according to the rules of Hindoo art, and sculptured from the basement to the bracket capital, which always forms the upper termination, the pillars are generally placed so as to be equidistant from one another all over the floor; but as there is always a wider aisle in the centre running to the door of the temple, and generally a similar one crossing it at right angles, this is obtained by omitting one, two, or even three rows of pillars, and replacing them constructively by attaching bracketing shafts to the fronts of the remaining side columns, and carrying forward from them a bold series of brackets carrying longitudinal ties and trusses, all in stone, till the space to be roofed by flat stones is the same, or nearly so, as that of the side aisles. Besides being used as porticoes to temples, an arrangement similar to this, of one centre and two side aisles on either side of it is used in some temples as a cloister surrounding the courts: at Ramissiram for instance, such a cloister extends for nearly 4,000 feet.

A still more extraordinary columnar arrangement is that of the *Choultries*, or nuptial halls,—usually called "halls of a thousand columns," and frequently containing exactly that number. At Tinevelly for instance, of which a plan is on the wall, the number is easily calculated, as the hall is 10 pillars in width and 100 in length; at Chelumbrum it is 24 × 41, which with the 16 pillars of its porch would make up the number exactly, but there some have been omitted in the centre, so as to allow of open spaces for the ceremonies, so that the actual number is 930; in many instances, however, there are only 600 or 700, but in none that I know of less than 500, and considering that in most cases all these are of granite, generally of one piece from 16 to 20 or 30 feet in height, and always carved from basement to capital with the most varied ornaments, it will be easily conceived what works of labour they must have been, and what impression of infinity of toil they produce on the spectator. I need not here enter into more detail on this subject, but may now proceed to point out how these various component parts of a temple are grouped together, so as to compose a whole.

The simplest and most general arrangement, at least for smaller temples, such as those found in villages, and some of the larger ones, as that for instance at Tanjore, is that of a vimana and its portico standing in the centre of a square court, surrounded by cloisters and inclosed by a high plain wall, with one gopura in front of the entrance to the temple. Few temples, however, except of the smallest class, are of so simple a form, but generally they are surrounded by a second inclosure, the sides of which are parallel to those of the first; say at the distance of about 100 feet. This is likewise surrounded by cloisters, and incloses several minor shrines, or temples dedicated to inferior deities. Generally it possesses two gopuras, the one in front of that belonging to the inner inclosure being generally connected with it by a handsome colonnade or mantapa, with an aisle at right angles to the principal one. The other gopura is placed behind the temple, and is of less importance than the one in front. Almost all the great temples of India possess a third inclosure with four gopuras, one on each face, thus making up seven in all. Besides minor shrines and Brahmins' residences, the outer court generally contains the great choultrie or hall of a thousand columns; and in this form the southern Hindoo temple may be said to be complete. In some instances a fourth, fifth, sixth, and even a seventh inclosure is subsequently added, and as each of these has a shrine with four gopuras, as in the famous temple at Seringham, a temple may have as many as twenty or twenty-three of these. This however may be said to be rather the exception than the rule; the temple being complete with three courts and seven gopuras. There is however another form, when the temple is dedicated to Siva, of placing two such as I have described side by side, one dedicated to the god himself, the other to the goddess Prava his wife. This is the case at Tinevelly and Madura, in either of which instances there are only eight gopuras, though had the design been carried out as if there were two complete separate temples and three inclosures, the number should have been thirteen, as there is only one temple common to both.

The dimensions of these buildings are very considerable; the outer inclosure, when there are three, seldom being under 500 feet, and ranging from that up to 1000, and even 1200 feet, the usual dimensions being about 600 or 700 feet. The gateways generally are, or are intended to be, in proportion to the length of the wall to which they are attached, thus the inner gateways are generally smaller than the external ones, though not in any exact proportion. In the great temple at Seringham for instance, the inner gopura is quite insignificant, while the outer four attached to the seventh inclosure would, if completed, have been the most splendid in India. Unfortunately they were commenced only in the beginning of the last century, and our wars with the French, and the consequent troubles of the country, put a stop to their erection. The principal one however is a nearly solid mass of granite, 150 feet wide by 100 feet in depth, pierced by a gateway, of 21 ft. 6 in. clear width and about 45 feet in height, roofed with large slabs of granite, 23 or 24 feet in length; had a pyramid of the usual proportion been added to this, it could scarcely have been less than 300 feet in height, which is more than double the usual size of such erections. The materials also, which were used in these gateways, are on the same scale, the door-posts being generally of one slab of granite, 30 or 40 feet in length, and covered with the most elaborate sculpture. The vimanas are seldom on the same scale as the gopuras, and it is one of the principal defects of these buildings, that they want a central point of attraction round which the subordinate ones are grouped. This arose in many instances from a village temple having become sacred, either from some supposed miracle wrought by the god, or some accession of wealth to the foundation—for there as here wealth works miracles—and instead of pulling down and rebuilding the original edifice, inclosures and gopuras were added to the utmost extent the means of the temple would afford.

Another cause was, the mysterious effects produced by the sanctuary not being visible from the exterior: but when you are immediately under the temple, or inside its walls, under its colonnades, the defect is not perceived. While, after passing under its gateways and from one court to another, each more holy and splendid than the last, the effect is certainly grand—when you behold before you the holy of holies, shrouded from human eyes by its high impenetrable walls, and can only peer through its colonnades into the mysterious gloom that shrouds the deity himself. At a distance, however, the defect in an architectural point of view is very striking; and though the number and size of the gateways tell always with striking effect, the mind is ever puzzled and unsatisfied by seeing them all facing different ways, and pointing towards something—and that something is wanting in every view. This, however, is not always the case: at Tanjore, and generally in the smaller temples, or those built on an original and uniform plan, the vimana is the principal object, and the gopuras and mantaps are all in proper subordination to it.

Before leaving this part of my subject, it remains for me to point out some similarities with other styles, which have often been insisted upon by others; and though I myself am not inclined to attach much weight to them, they are still interesting, and others may be inclined to take a different view of the matter from that which I take of it. The first is its presumed identity with Egyptian architecture. In looking, for instance, at the plans of the temples at Karnac or Edfou, we find two or three successive inclosures of high dead walls surrounding the sanctuary. The same and indeterminate number of predominant high massive propyla, which form the only object seen outside; while the sanctuary is low and concealed by the high walls that surround it. The great choultries, besides are both in position and apparently in use similar to the hypostyle halls of these temples; and the propyla are in both instances the great Iconostases, or image-bearing screens of the temple. I may also add, that the same successive mode of erection was, at least in some instances, followed in both cases.

These certainly are strong points of similarity, and at first sight almost conclusive. But on a closer examination they are overpowered by the extreme dissimilarity of design and principle; by the total absence of hieroglyphics, or hieroglyphic expressions, in the Indian examples; and by the utter dissimilarity in every detail between a style so exuberant in strength as the Egyptian, and one so tending to frailty as the Indian. Still, the difference may only be such as exists between the Norman and florid Gothic styles, whose connection no one doubts. It is easier, however, to point out similarities than dissonances, and there are some points in which all masonry styles must resemble one another. It is only by weighing fairly the two styles by one, and by an accurate knowledge of both, that any one can be able to arrive at a just conclusion on the subject. I have myself been so staggered at times by the points of resemblance, that I have been inclined to accede to the general opinion; but on the whole I fear it must be considered in the present state of the question, as too hasty a generalisation.

The similarity that exists between these temples of the south of India, and that at Jerusalem, as described by Josephus, is even more striking and puzzling than that just pointed out; but as it would require large drawings, and more space than I can here afford, to make this intelligible, I will not insist here on what may be after all merely accidental.

It only remains that I should in conclusion say a few words on the general architectural effects of the examples I have been describing. I cannot of course ask you to admire them, nor to agree with me in my estimation of them, for I am aware that to you they must seem both strange and uncouth, if not positively ugly. So at least they appeared to me when I first became acquainted with them, and it was only after I was thoroughly accustomed to their form, familiar with their details, and more than this, thoroughly understood the motives and meaning of every part, that I could see either beauty or design in them. Nor do I think this ought to surprise any one, who recollects how short a time ago it is since every man of taste thought it necessary to characterise the Gothic style as a barbarous jumble of ill-connected incongruities, which our fathers—not even our forefathers—mutilated without mercy, and thought it the greatest merit to hide and obliterate whenever an opportunity occurred. By degrees we came to understand the style, and by deep study of it found out that pinnacles, buttresses, banded shafts, and other peculiarities, which so far from being mere barbarous caprices, were motived elements of construction; and when once we were familiar with the details and understood the construction, all was beauty and order, where only deformity and caprice seemed to exist. So it is with these Indian styles; a man must be familiar with the climate and the people where they are found, must understand their manners and religion, and must familiarise himself with all the peculiarities of the building, before he can either appreciate or admire them. Once, however, he is educated to this, I think he can scarcely fail to perceive beauty, rising sometimes to sublimity, in the immense colonnades, and in the massive propyla and spacious courts of these temples, all of which are constructed on well-defined principles, and all consequently producing the effect the architect designed they should produce on the spectator.

I have learnt to admire these styles in their own country, and do admire them in many respects: but I should be sorry if any one should interpret this expression of admiration on my part as if I were recommending them as models to be transplanted to this country, or as containing anything that could be successfully imitated here. On the contrary, the lesson which the study of these exotic styles seems to me to teach, is diametrically opposed to this, and goes to show that every age and every climate has its own appropriate style, beautiful and appropriate when so used, but absurd and incongruous when either transplanted to another climate, or copied in another age.

Another lesson, which a very slight study of these styles would convey, is the knowledge of the infinity of forms into which stone may be wrought for building purposes. For nearly two centuries all Europe believed that the Roman forms were the only ones capable of producing architectural beauty, and consequently, from the Reformation till the beginning of this century, no other details were used, though their incongruity was frequently ludicrous. Stuart and Revett, and their followers, taught us that we had been copying a corruption, and we in consequence found out that pure Greek details were the only ones worthy of notice. We have now transferred our affection to Italian and Gothic. A large view, however, of the question, and one to which I conceive the study of the Indian, the Saracenic, the Mexican, and all the other exotic styles would inevitably lead, would show that the forms of architecture are not confined to three or four styles, but are infinite, and so far from being exhausted by those who have gone before us, so as to reduce us of necessity to the mere rank of copyists, as has been often asserted, and would prove we do not yet stand beyond the threshold of invention in this branch; but that new forms spring forward at the bidding not only of every cultivated man who thinks, but even of the savage or the half-civilised man, who tries to express in stone the idea with which he is filled.

The most important lesson, however, that can be derived from the study of these monuments arises from the fact, that they are built by persons who seldom can read or write, and who never can draw, in the European sense of the term at least, and for a people who have neither a written literature nor history of their own,—who have no institutions worthy of the name, and whose religion is one of the grossest superstitions that ever disgraced humanity. Yet these people could invent and perfect a style of their own, which should not only express their own feelings and civilisation, but convey to posterity a higher idea of that civilisation than we can obtain from any other source, and which we with all our cultivation must be content to admire, but have not yet dared to emulate.

Remarks made at the Meeting after the reading of the foregoing Paper.

Mr. **Fergusson** having concluded his paper, the Chairman, Mr. Scoles, and other Members, put several questions to Mr. Fergusson, who explained, that in nine cases out of ten, all the upper part of the vimana, above the first story, was a mass of solid brickwork. There were small chambers in each story; but they were not used for any purpose, and were obviously made for the object of saving material. Access to them might be obtained by hidden staircases. No skill in construction was exhibited; it was a mere piling up of material. The immense stones used in building the gateways were raised on end or placed across, simply by force of the immense numbers of hands employed. They covered the stone to be raised like ants, and by inserting bamboos after the manner of wedges, literally "shove" it up. He could not use a more dignified term to describe the operation. There was a column 80 feet in height erected at Seringapatam, in memory of Sir David Baird: it was put up in this way. There were no indications of the arch in these sacred buildings.

Mr. **Tite.**—The lecturer has described this architecture as being of a character *sui generis*, and I am quite of his mind. At the same time I must say that I have been much interested by the beautiful drawings of Central America, prepared by Mr. Catherwood, a member of the Institute; and I have been led by the extraordinary character of the ruins depicted by him, to endeavour to trace the people to whom they are to be attributed. Philological analogies are quite at fault. The language of the people, and that of the other races of India are entirely different. Now I cannot help fancying that I can see a great similitude between the sketches now submitted to us and those of Mr. Catherwood. The Mexican architecture is akin to that of Yucatan, and the characteristics of the latter may be traced in that of Java. It is undoubtedly an immense distance from the south-east point of Hindostan, the architecture of which has this evening so ably been brought before us; and the totally different character of the languages—they having no cognate root—a still greater obstacle. Yet I think this may turn out one of those cases, in which the comparatively imperishable character of architectural remains will aid us more in tracing the connection of races than even philology. Sir Stamford Raffles describes the temples of Java to be pyramidal edifices, like those of Southern India. That is the case also in Mexico, the altar being placed on the top, and the carcases of the victims thrown down the steps. It may be after all, that these resemblances are only those created by the common requirements of a similar climate. I agree with Mr. Fergusson that the supposed resemblance of the Egyptian architecture is not worth consideration. It arose no doubt from the wonder of the sepoys on visiting Egypt; but an uneducated eye would fancy a resemblance, where that of an instructed person would at once decide that there was no real resemblance at all. There is nothing in the architecture of any of these countries to suggest a belief that they are of enormous age. Despite the almost insurmountable difficulties that present themselves, I cannot help thinking that there was a connection between the widely separated races, geographically and philologically speaking, by which these buildings were erected.

Mr. **Fergusson.**—Javanese architecture is acknowledged to be Hindoo. I know the Hindoo architecture well, and when I was in Java I satisfied myself of the fact. With regard to Mexican architecture, I can only say, that I went carefully over Mr. Catherwood's drawings with him, and we agreed that it had no resemblance to India; all the similarity arises from their being both of a rude style generally, with details most exuberant,—the characteristic of all rude styles. The religion of the Mexicans is totally different from that of India; the latter has not human sacrifices, and in fact no pyramids. They have pyramidal gateways, but altars they have none. In the one case the sacrifices took place always in the sight of the people; in the other the rites are performed secretly inside the temples. In Java, the religion is in fact a branch of Buddhism from the Indian continent.

Mr. **Billings** thought the models exhibited had a striking general resemblance to the pagodas of the Chinese. We had long prided ourselves in England as the originators of the four-centred arch, but in the drawings now exhibited there it was.

Mr. **I'Anson** thought the paper just read proved that the subject was one which the government of a great nation like England would do well to take up; particularly as our connection with India was so close. With regard to the architecture before them, he saw in some of it a resemblance to the Greek and even to the Roman tombs.

Professor **Cockerell** was anxious to acknowledge the great advantage the lecturer had conferred on the Institute, by making known this new family of architecture. It was an interesting fact, that at the extremity of this peninsula there should have arisen a people, whose architecture was so different from all others known. With regard to the peculiar character of the present architecture and its analogies, he must say, that he thought the difference of climate was productive of most of the distinctive features of the styles of different countries. The Jewish temple, for instance, was built in a climate which required those extensive porticoes; and accordingly in the temple there was the inclosure and the portico; and in like manner, in this extraordinary grouping of Indian architecture, a similar arrangement was united, and hence the halls of a thousand columns. Human nature was the same in every climate, and the same feeling which made the shrine of Our Lady at Loretto to be visited by pilgrims from all parts of the Christian world, was traceable in the small temples of India, which, having acquired the odour of a peculiar sanctity, became large temples surrounded by many walls and dignified by many columns. A most instructive study would be that of models of the temples of all religions in the world, by which the similarities of all would be brought out, and their differences traced to their various causes, and particularly in reference to the climate. They had all reason to thank Mr. Fergusson, for the clearness and completeness of the account he had given of this extraordinary architecture.

Mr. **Fowler** reminded the meeting that one of its honorary members, the Rajah of Tanjore, had presented them with drawings of these very temples. He supported the views of Mr. I'Anson, with respect to the duty of the Government, or of the East India Company, to take up the subject.

Mr. **Godwin** informed the meeting, that the local papers of India had become strongly alive to the importance of the subject, and the East India Company were doing something for the preservation of these relics of departed generations.

Mr. **Fergusson** said that the East India Company had taken 40 copies of his work on India, and in consequence of that publication, orders had been sent out to employ persons to make copies of all decaying remains, ere they disappeared altogether. This was done with some ardour until the wars put a stop to the work. Capt. Gill, however, had been three years at work with a large staff, making copies of the celebrated frescoes in the Ajunta Caves. Thirty or forty large paintings, representing the manners and customs of the people during the last 1200 years, had been received at the India House. They were facsimiles of the paintings in the caves. The work was now going on slowly, but would, he hoped, ultimately present a complete illustration of most of the monuments of the past existing in India.

Mr. **Papworth** inquired whether, as Mr. Fergusson had in his former lecture spoken of five styles, there was any evidence of the duration of each; and whether the character of the religious worship was impressed on the temples. He should also like to know, whether the work of Ram Raz was valuable or not.

Mr. **Fergusson** said there was no difficulty in determining the age of the works, for the farther they went back the more perfect they were in respect to the carving. The buildings used for temples could not be mistaken for anything else. In the estimation of a native, the newest, the latest built edifice was always the most handsome and the best. That was the chief fault of the work of Ram Raz; but with that exception, and also some geometrical defects in the drawings, the work was valuable. It had however no details to which an European could work.

ENGINEERING PROGRESS.

The Institution of Civil Engineers having elected Mr. William Cubitt as their President, that gentleman, according to custom, has delivered an inaugural address (January 8); wherein he takes a rapid but interesting review of the chief engineering triumphs of the past year, and points out the new fields of usefulness opening up to the inventive powers of man in the mechanical sciences.

After thanking the members for the honour conferred on him, and modestly attributing his election to the fortuitous circumstance of his being "the senior Vice-President in duration of office," rather than to any peculiar fitness on his part, he proceeded to direct attention to some matters relating to the internal policy of the Institution, and proposed that the evening meetings should terminate at half-past nine o'clock, in order to afford an opportunity for the members and visitors to assemble in the library, and to obtain those personal introductions to each other which constitute one of the great advantages of all societies.

He then announced, that the Council had, with great pleasure, acceded to the recommendation of the last Annual General Meeting, and had invited Mr. Walker, Sir John Rennie, and Mr. Field, the past Presidents, to take their seats at the Council table, in the Council-room, and in the Theatre, as "Honorary Councillors," and that, in future, all those members who should fill the posts of Vice President and President consecutively, holding the latter position for two years, should be considered "Honorary Councillors"; expressing a hope, that the past Presidents might long be spared, to continue that assistance from which the Institution had already reaped so much advantage.

He then announced, that, as the representative of the Institution, he had been nominated a member of the Royal Commission for the promotion of the Exhibition of the Works of Industry of all Nations, under the auspices of H.R.H. Prince Albert, and requested the aid and cordial concurrence of all the members in that "real Peace Congress."

Mr. Cubitt then proceeded to notice the principal engineering works now in progress, or lately completed, as arranged under their respective heads, as follows:—

Tubular Bridges.—Although during the past year there has not been so great a demand for the talents, or the energies of engineers, several remarkable works have been finished, or have far advanced towards completion; I will allude briefly to a few of them, and if others of importance escape notice, it must be attributed to the engineers not having brought accounts of them before the Institution, or even incidentally mentioned them in the discussions. Among these, the tubular bridges across the river Conway and the Menai Straits, are pre-eminent, for the boldness of the conception, the scientific simplicity of the design, and the difficulty of the execution. In tracing the original idea of the most advantageous disposition of a certain amount of material, in a tubular form; the more definite conception of a hollow beam, to permit the passage and support the weight of an engine and train; the experiments for determining the proper distribution of the material, to prevent compression, or disruption; the arrangement for the construction and building up these gigantic masses of material; the means of floating them to their situations, and of raising them to their ultimate destination, at an elevation of 102 feet above the sea (at high water of spring tides);—we must feel justly proud of possessing among us the man whose comprehensive mind could originate this magnificent design, and so successfully perform a portion of the work as to leave no doubt of its ultimate accomplishment. The world already duly appreciates this great undertaking, and we should not be behindhand in testifying our estimate of the bold conception of Mr. Robert Stephenson in the original idea, his professional skill in the design and execution, his care and caution in availing himself of the talents and experience of Mr. W. Fairbairn and Mr. Eaton Hodgkinson, whose scientific investigations respecting the strength of cast-iron, are so well known to the world and so highly appreciated by our profession, and his intrusting the general construction and elevation to Mr. Frank Forster and Mr. Edwin Clarke. Upon the merits of all these gentlemen we may look with pardonable pride and partiality; their labours speak for themselves. However advantageous may be the results of this construction, in facilitating an important communication I shall have occasion to allude to hereafter, it has already been extremely useful in directing attention to the more general employment of wrought iron for the purposes to which it had not previously been deemed applicable; and it will be found that its introduction to structures of all kinds will become more common, exactly as the method of using it becomes better understood.

Report on Iron.—May I here be permitted to diverge for an instant, in order to direct attention to a subject of considerable importance to the profession. In the year 1847 a commission was appointed (of which I was named a member) for the purpose of inquiring into the conditions to be observed by engineers, in the application of iron, in structures exposed to violent concussions and vibration; and for endeavouring to ascertain such principles and forms, and to establish such rules as should enable the engineer and the mechanic, in their respective spheres, to apply the metal with confidence, and should illustrate, by theory and experiment, the action which would take place, under varying circumstances, in the iron railway bridges which had been erected. Numerous witnesses of great theoretical attainment and practical experience, were examined before the commission, and a very interesting series of experiments was carried on, for ascertaining certain points relative to the compression and extension, the tensile and crushing strength, the effect of statical pressure, and of vibration, concussion, &c. The result of this laborious investigation is (in the words of the report, which is now before the public) that 'considering that the attention of engineers has been sufficiently awakened to the necessity of providing a superabundant strength in railway structures, and also considering the great importance of leaving the genius of scientific men unfettered for the development of a subject as yet so novel and so rapidly progressive as the construction of railways, we are of opinion that any legislative enactments with respect to the forms and proportions of the iron structures employed therein would be highly inexpedient.' It would be foreign to my present purpose to enlarge upon the importance of this decision; but I must recommend the Report to your careful perusal and consideration.

The *Harbours of Refuge* now in progress are works of national utility. Those at Dover and in the Channel Islands, by Mr. Walker, deserve particular attention. The former has already produced extraordinary effects on the litoral currents and in the movement of the shingle on the coast, and the latter will afford protection to the storm-driven mariner, where he before expected only danger and death. The Breakwater off Portland Island is important, not only as utilising one of the finest bays on our coast, but also as an immense engineering work, intended to be executed almost entirely by convict labour, and on that account it was necessary to render its construction as simple as possible. This has been achieved by Mr. Rendel, whose design is to form along the site of the intended breakwater a timber staging, carried upon screw piles; on this will be laid railways connected by inclined planes with the quarries on the hill, whence the trains of stones will be brought, and their contents be distributed simultaneously, and in regular thickness over given areas, enabling a careful admixture of large and small materials to be effected, and the whole mass to rise gradually to the surface, and being thus self-supporting, to prevent the washing away of the materials, which has been experienced in other works of a similar nature. The harbour at Holyhead, and the new docks at Leith and at Grimsby, also by Mr. Rendel, do equal credit to his comprehensive designs and his executive skill.

Lighthouses.—In conjunction with these maritime works may be mentioned two lighthouses, both possessing remarkable features. The first is an iron structure, erected on the Bishop's Rock, by Mr. Walker. It is situated about 30 miles from the Land's End, Cornwall, and four miles due west from the St. Agnes Lighthouse, which would probably not have been constructed had our ancestors possessed the modern facilities for the execution of works of this nature. The position is more exposed to the force of the Atlantic than the famed Eddystone Lighthouse, and the surface of the rock is of such an outline as scarcely to admit of a solid building. It was therefore determined to erect such a structure as should offer little or no opposition to the waves, and bear a light at such an elevation as to render it extensively useful. Six hollow cast-iron columns, with a strong bar of wrought iron in each, sunk to the depth of five feet into the rock, forming at the base a hexagon 30 feet in diameter, and tapering upwards, support, at a height of about 100 feet, the dwelling of the three light-keepers, with stores and provisions for four months, the whole being surmounted by the lantern. The access to the dwelling is by a centre column of cast-iron, containing a spiral staircase. The difficulties overcome in the execution of this bold design can scarcely be appreciated without a more detailed account of it, which, however, I trust, will be laid before you during this session.—The other is a stone lighthouse, called the Skerryvore, erected by Mr. Alan Stevenson, on a small desolate rock situated about 11 miles W.S.W. of the island of Tyree, and 90 miles from the mainland of Scotland. The rock is exposed to the fury of the North Atlantic, and is surrounded by an almost perpetual surf. The talent and perseverance of the engineer enabled him, however, to complete, without loss of life or limb—great as were the difficulties he had to contend with—a structure far exceeding the dimensions of the famed Eddystone and Bell Rock Lighthouses, their relative heights being—the Eddystone, 68 feet; the Bell Rock, 100 feet; the Skerryvore, 138 ft. 6 in. The difficulties of the construction, the merits of the structure, and the system of lighting, are so fully described in Mr. Stevenson's published account of it, that it is not necessary for me to do more than to point to it, as one of the remarkable works of the present day of which we have justly reason to be proud.

In *Steam Navigation* great efforts have been made by some of the principal marine engineers and the builders of wood and iron vessels. The result has been the production of four steamers, with engines by Messrs. Seaward, Miller, Penn, and Forrester, in vessels built respectively by Messrs. Mare, Miller, Thompson, and Laird, for conveying the mails; and an equal number of engines by Messrs. Maudslay and Field, Forrester, and Bury, in vessels by Messrs. Wigram, Mare, Laird, and Vernon, for carrying passengers between Holyhead and Dublin, which have attained the speed of nearly 18 miles per hour, and accomplish the passage, on an average, in four hours. By these means when the Britannia tubular bridge is completed, the journey between London and Dublin may be accomplished within 11 hours. This is an extraordinary advance upon the opinions of only a few years since, when it was reported to be possible to perform the same distance in 14 hours. The excellent machinery of Messrs. Maudslay and Field, and of Messrs. Forrester and Co., in the iron steamers built by Mr. C. Mare and Mr. J. Laird, have also contributed mainly in accomplishing a journey to Paris, as we have recently seen it performed, in eight hours and a half; giving a death-blow to the onerous system of passports, which hitherto interfered so materially with that free and unrestricted communication so essential for the mutual benefit of the two countries. In the accomplishment of this rapid communication with Paris, I may be permitted to feel som pride, as, in my capacity of engineer of the South-Eastern, and in my professional connection with the Boulogne and Amiens railways, the possibility of expediting the intercourse between the two capitals constantly occupied my mind; and so long ago as in June, 1843, before the present fast steamboats were placed on the station, I undertook and accomplished the task of conveying the directors and their friends from London to Boulogne, and home again, between 6 o'clock in the morning and 10 o'clock in the evening, with a sufficient interval for a public reception at Boulogne. Among the builders of steam-vessels, Mr. Scott Russell must be particularly mentioned, for the successful investigation and application of the wave lines to the forms of vessels, so that the curves of least disturbance can at once be adapted to a vessel the ultimate, or greatest velocity of which has been previously determined; and thus high speeds, and easy motion through the water, can be attained; whilst a given immersion is arrived at with certainty. These points were remarkably shown in the *Manchester*, a vessel for carrying passengers across the Humber, at New Holland, and with its consort steamer the *Sheffield*, constructed by Messrs. Rennie, becoming as it were floating bridges, completing the line of the Manchester, Sheffield, and Lincolnshire Railway, and conveying the contents of the trains, from point to point, at a speed of about sixteen miles an hour.

In connection with this railway must be mentioned, the large pontoon, recently built by Messrs. E. B. Wilson and Co. (of Leeds), from the design, and under the direction of Mr. John Fowler. This immense iron vessel, which is four hundred feet long, fifty feet wide, and eight feet deep, with a deck area of twenty thousand square feet, serves as a floating landing stage, for these fast passage-steamers, rendering the railway trains independent of the tide, and of the muddy shores of the Humber.

The deck-area of this landing stage is about half that of a somewhat similar structure, built a short time previous, from my designs, and under my direction, at Liverpool, and of which a description and drawings will be prepared for an early meeting of the Institution; as an earnest of my intention to practise what I have ventured to impress upon all those, who not only possess the information, but the power of imparting it, for the benefit of their professional brethren.

A number of fine steamers have also been constructed, for the Government, for private companies, and for foreign States, in which the beautiful engines of Maudslay and Field, Miller, Seaward, Penn, Napier, Rennie, and others, have fully maintained their European reputation.

Railways.—This incomplete sketch of a few of the engineering works of the past year, leaves untouched that vast subject, the Railway System, towards the completion of which, much has been accomplished within the last twelvemonths, without that public excitement which accompanied all its former progress. There are now nearly five thousand five hundred miles of railway completed in Great Britain, at a cost of about two hundred and twenty millions sterling, which immense sum, derived from private sources, has been expended within the realm, encouraging in an extraordinary degree, productive industry of all kinds, and inducing a revolution in all mercantile transactions and social relations. The Steam Engine and the Power Loom have been regarded by the sober-minded political economist, as the real sources of the power and influence of Great Britain, and though the gallantry of her hardy sons, both in the military and naval services, may have been more publicly apparent, and were, in fact, inestimably valuable when called into action, it is the productive classes of this country that constitute its real strength. The example of England, in boldly abandoning the finest roads, and adopting throughout the length and breadth of the land, a network of iron ways, over which, by the aid of steam, passengers and merchandise are conveyed at a velocity, which, at its first proposition, was by the world deemed worse than visionary, first filled our continental neighbours with astonishment, and then compelled their imitation, so that within a few years, by this new power, the relative positions of the continental states are changed, and the ultimate effect must be to introduce wants, and consequently civilisation, to the most remote corners of the earth.

If this be true, we are naturally led to inquire who were the authors of this great revolution, what minds conceived, and what energies executed these vast projects, thwarted and controlled, as they must have been, by vested interests on the one hand, and the necessity of urging into action a whole nation, before such a momentous change could be effected. The reply, Gentlemen, must spring spontaneously from you all. The Civil and Mechanical Engineers have been the great actors in this most interesting chapter of the social history of our country; and if we may look back, almost with reverence, to the splendid careers of Arkwright, Brindley, Smeaton, Jessop, Mylne, Ralph Walker, Dodd, Watt, Telford, Rennie, and a host of other illustrious names, we may with equal pride look around upon the men of our own time, whose voices have frequently been heard within these walls, instructing and urging us onward in the course they had so successfully followed; some of them are removed from us, but the names of Rennie, Walker, Stephenson, and Brunel, are yet here, and they have left worthy scions to complete the works they so nobly commenced. One great duty the departed have enjoined on us—the record of their works and of our own; and let us remember, that if we desire to hand down our names to posterity, as useful members of society, it is our duty to render this Institution the depository of the accounts of our works, that the future historian of this eventful age, may find in our archives, not only accounts of the works themselves, but of the men who conceived and accomplished them, and to whom their country is so deeply indebted.

For the junior members of the profession, many of whom have already given indications of talent and power, auguring well for their future fame, a wide field is opened in the sanitary question, which embraces the subjects of the drainage and sewerage, the paving, lighting, and cleansing of cities and towns; the more copious and less expensive supplies of water and gas; and, in conjunction with the architects, the improvement of the dwellings of the labouring classes; the establishment of baths and wash-houses; and the introduction of abattoirs.

In this latter portion of the question, the railways should act an important part; for if their establishment has created a wish, or a necessity for travelling, and produced great changes in commercial transactions, by rendering unnecessary the intervention of a third person between the manufacturer and the tradesmen, it would appear feasible to use the same facilities for bringing up from the country large supplies of animal food, ready for sale, instead of the living animals, to be slaughtered in a crowded city, and introducing noxious and unhealthy trades, for using up those portions not fit for food. If, as we have been recently informed by the journals, there be a great discrepancy in the prices of food, between London and the country towns, the aid of the railways should be invoked, and the same producers should be glad to avail themselves of an opportunity of supplying the metropolis, in such a manner as would soon equalise the general prices.

The engineers have always been the real sanitary reformers, as they are the originators of all onward movements; all their labours tend to the amelioration of their fellow-men; and though in times past the introduction of machinery was looked upon with jealousy, education has now happily caused a more just appreciation of their labours; indeed they would deserve the highest encomiums if only for the application of steam, which, in production alone, now represents the power of forty millions of human beings, who, even if they had been able to perform the labour, would have been degraded by it to the level of mere animals, instead of thinking creatures, sent each to perform his part in the complete system of social life.

The heavy demands on the invention and skill of engineers, in the construction of railway works, during past years, have left but little time for the devotion of their energies to the improvement of the mechanical and commercial working of the lines. A wide field is, however, now opened for the exercise of professional skill and ability, in perfecting the applications of tractive power, and all the machinery of railway plant; and it may be reasonably expected, that the opportunities thus afforded to railway companies, of bringing the highest engineering skill of this country to bear upon these questions, may not only produce great economy in the working expenses, and greater efficiency in the general plant, but lead to radical improvements in the construction and maintenance of the destructible parts of the (so called) "permanent way," and thus set at rest the question of depreciation—a desideratum which is now felt to be of almost vital importance to railways as an investment.

I feel, Gentlemen, that, hurried and imperfect as this sketch may be, the subjects have carried me far beyond the limits I had originally intended; and I must request your indulgence for having occupied so much valuable time. You will not, however, find me so trespass upon you again; and, with reiterated thanks for the honour you have conferred on me, I will at once enter on the duties of the office, and proceed to the regular routine of the evening meeting.

MORTON'S IMPROVED PATENT SLIP.

Patent Hydraulic Purchase Machinery, applied to MORTON'S *Patent Slip, by* Mr. DANIEL MILLER, C.E., *St. George's-road, Glasgow.*

The great advantages of "Morton's Slip" over all other modes of docking vessels for repairs, &c., in speed, economy, and efficiency, have been long established by the evidence of the ablest scientific authorities, and its practical operation in many ports of the United Kingdom and other countries. The present improvements on it increase these advantages in an eminent degree. They consist in the substitution of improved hydraulic purchase machinery, instead of the system of wheel-work at present in use, and possess the following recommendations:—

1st. That the improved machinery can be laid down for less than one-half the cost of the present machinery; for very large slips much less.

2nd. Ships will be taken up at double the speed, as but a very small proportion of the power is absorbed by friction; and, from the machinery being self-acting, no time is lost by stopping it to take a fresh hold.

3rd. The motion in drawing up a ship is so perfectly smooth and uniform, that no part of the carriage or ship is exposed to any undue strain.

4th. It occupies little space, is not subject to breakage or derangement, and the same foundation does for both purchase machinery and steam-engine.

Description.—The engraving, fig. 1, is an elevation of the purchase machinery, in which A, represents a hydraulic cylinder, fastened securely to a firm foundation at the upper end of the slip. It is fitted with a moveable ram B, working through cupped leathers at the neck. Two side rods, *d*, proceed from a crosshead on the end of the ram, along the sides of the hydraulic cylinder to another crosshead E, where the traction rods are fastened, connecting it with the carriage on which is the vessel to be drawn up on the inclined plane, as represented in fig. 2, on a smaller scale. The traction rods are each of the same length as the ram. F, is the cylinder of a steam-engine with its connecting-rod communicating a rotary motion, by means of a crank, to the shaft *g*. On the shaft are other cranks for giving a reciprocating motion to the plungers of two or more pumps H. A fly-wheel *c*, on the shaft regulates the motion of the whole.

Fig. 1.

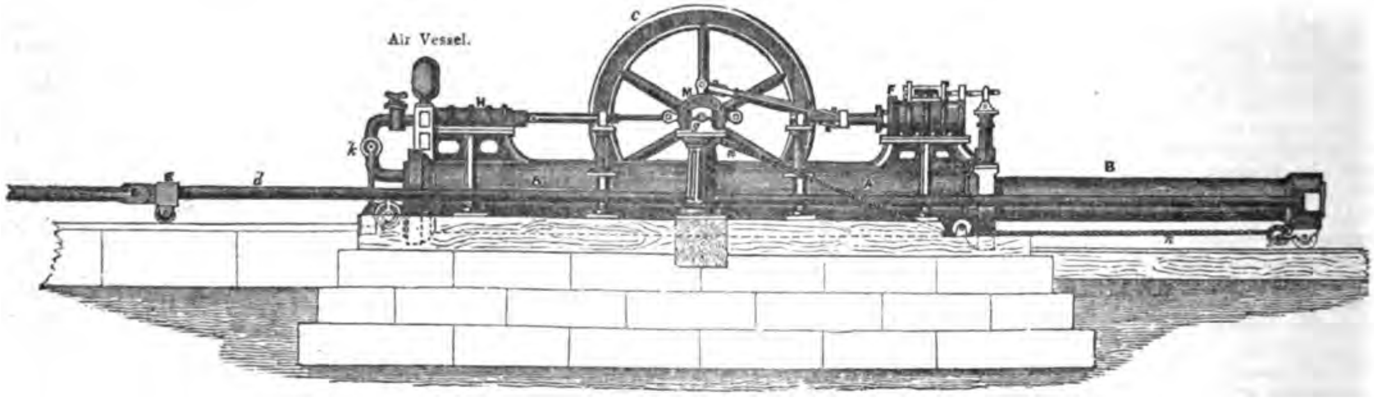
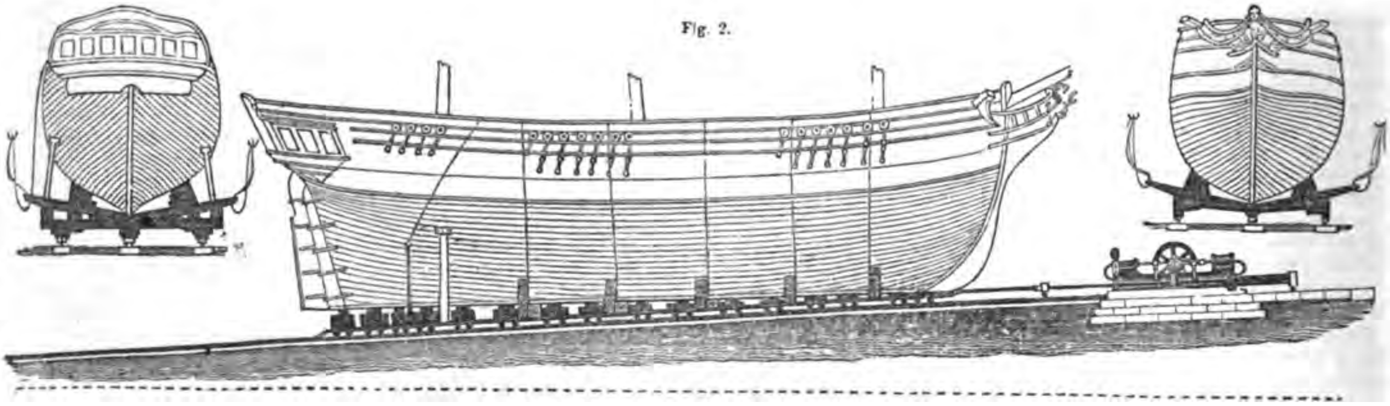


Fig. 2.



Mode of Action.—The carriage having been run down the inclined plane or "slip," the vessel to be taken up is floated on it, and properly blocked up and secured. The lowermost traction-rod of the purchase chain is then attached to the middle or keel-beam of the carriage, and the purchase machinery at the head of the slip is then put in action. The ram of the hydraulic cylinder is supposed to be at the beginning of its stroke, its crosshead being down at the top of the cylinder. By the action of the piston of the steam cylinder F, the cranks on the shaft are made to revolve, putting in motion the pumps H, which abstract water from an adjoining reservoir, and force it into the hydraulic cylinder. The ram is thereby made to move steadily up out of the cylinder, with a force in comparison with the steam-engine, as the area of the forcing pumps to the area of the ram; and, by means of the side-rods *d*, communicates the motion to traction-rods connected with the carriage, which, with the vessel on it, is thus hauled up on the rails of the slip. When the ram has moved out of the cylinder to its full extent, or completed its stroke, the traction-rod (being the same length as the stroke) nearest the top is removed. At the same time self-acting apparatus shuts the cock *k*, for admitting water from the pumps into the hydraulic cylinder, and opens another *l*, for the eduction of that which has been forced in, whilst a roller M, on the shaft is put into gear and winds round it a rope or chain *n*, proceeding from the crosshead of the ram, and speedily brings back the ram into the cylinder to its former position, ready to take a fresh hold. The next traction-rod of the purchase chain is now attached to the crosshead E, while the self-acting apparatus is reversing the cocks, and putting the winding-up roller out of gear. The same action as before again takes place, and the ram moves up to the end of its stroke, when another traction-rod is knocked off, and the ram returns to be attached to another. And so on, by a succession of these movements the carriage, with the ship upon it, is steadily and quickly drawn up on the slip to the distance required.

When not employed for hauling up vessels, the steam power may be rendered available for working circular saws, grindstones, and other apparatus required in ship-building yards.

The foregoing represents steam as the motive power employed for working the hydraulic purchase, but, of course, if preferred, manual or other power may be substituted with similar advantages.

GREAT SUSPENSION BRIDGE IN RUSSIA.

Considerable interest has been excited in St. Petersburgh by a remarkable model of a suspension bridge across the river Dnieper, at Kieff, one of the principal cities of Russia. This model was made in London, where it was exhibited to most of the principal engineers and architects. It has since arrived in St. Petersburgh, and has been put up in one of the grand saloons of the Winter Palace, where it was formally presented to his Imperial Majesty on his *fête* day (18th of December), by Mr. Vignoles, the English engineer, from whose designs, and under whose immediate directions, this bridge is now constructing.

The Dnieper is one of the largest rivers in the Russian empire, rising in the vicinity of Smolensko, and flowing in a southerly direction it enters the Black Sea, to the eastward of Odessa. In a broad geographical sense, the Dnieper may be considered as the easternmost boundary between Russia Proper (or Muscovy) and the great kingdom of Poland, which once extended westward nearly to the Giant Mountains of Bohemia, southward to the Carpathians, and northward to the Baltic. The principal city entered by the Dnieper in its long course to the sea is Kieff, celebrated in history as the first spot whereon Christianity was planted among the barbarous hordes then leading a nomadic life over the steppes of Russia, is well known also as an important military frontier post, alternately possessed by the Poles and by the Muscovites, and at present rising into great importance as the capital of the south of Russia.

Kieff is most picturesquely situated on the right or southern shore of the Dnieper; it covers a great extent of space, with numerous public buildings crowning the many heights of the undulating ground on which the city is built. The general aspect of the city is very striking, and the impression on a traveller from the western parts of Europe is that which he would expect to receive on first viewing some Asiatic capital. The commercial part of the town, called the Podol, lies on a low plain at the western extremity; the rest of Kieff is elevated from 200 to 300, and even 400 feet above the level, overlooking all the left or northern shores of the Dnieper, which are low and flat marshes, extending for many leagues above and below Kieff, and from one to two leagues wide. In the spring the whole becomes a lake, as the waters rise; the only approach from the north to Kieff is along a causeway raised above the level of the floods. It is from the end of this causeway that the suspension bridge is thrown across the Dnieper to the foot of the steep acclivities on the right bank. The river, which, for several leagues above, has spread through numerous lateral channels, here unites into one deep bed, and presents the narrowest passage. This passage is, however, still half an English mile in breadth, the depth of the water, in a dry autumn, being upwards of 30 feet in the streamway, and sometimes more than 50 feet after the melting of the snow in spring. Over this chasm, which once formed the barrier for Poland against the invasion of the Muscovites, the necessity of internal communication and the general march of improvement has called for the erection of a permanent bridge, and with enlightened policy the Emperor of Russia has ordered such a bridge to be constructed.

The soil of the bed of the river being wholly of sand, and the current often changing its channel, considerable difficulties presented themselves, while the tremendous breaking up of the ice after winter followed by the melting of the snows in the more northern districts, swelled the stream to an extent scarcely comprehensible to the inhabitants of Great Britain. It became, therefore, a necessary condition that the number of piers of any bridge to be built there should be the fewest possible, with the largest openings between them. Hence it seemed most natural that, with the given limit of expense, the principle of a suspension bridge should be preferred, and the designs were so prepared accordingly, and submitted to his Imperial Majesty. On Mr. Vignoles' urgent recommendations, the use of wire ropes as the means of suspension was negatived, and the adoption of wrought-iron chains with broad flat links was decided on. Such was the system employed for the Menai and Conway bridges in Wales, by Telford; at several places in England; and also in Hungary, at Pesth, across the Danube, by Tierney Clarke. All these bridges, however, have but one central opening. The suspension bridge at Kieff has four principal openings, each of 440 feet, and two side openings of 225 feet each, and also a passage of 50 feet on the right shore, spanned by a swivel bridge, opening for the passage of the steamboats and other river craft. There are, therefore, five suspension piers in the river, one mooring abutment on the left bank, another mooring abutment on the Kieff side of the stream (which, on account of the passage for boats beyond it, is actually an island of masonry in the river,), and an abutment for the swivel bridge on the right bank. Each of these have required a cofferdam of unusual size—particularly the two last mentioned. The architecture of the river piers is rather novel, and of a striking character, harmonising with that used in the extensive range of first-class fortresses which crown the heights of Kieff. The ways through the piers have a clear breadth of 28 feet, and a height of 35 feet to the soffit of the semicircular arches. The platform has nearly 53 feet of extreme breadth, of which 35 feet are exclusively devoted to the carriage-way; the platform is suspended by chains, all on the same horizontal plane, two on each side of the road; the footpaths project beyond the chains, and are carried by cantilevers round the piers exteriorily, so that the foot passengers are completely separated from the horsemen and carriages. The chains are composed of links 12 feet long, and each weighing about 4 cwt.; eight links form the breadth of each chain, and the total length measured along their curves being about four English miles. For the swivel bridge the iron employed is almost exclusively malleable; the breadth of the platform is nearly 53 feet, and the weight of iron employed scarcely exceeds 100 tons. The bridge is moved horizontally (on the same principle that locomotive engines are sent round on the large turntables at a railway station), and by the efforts of four men only, acting on a very simple apparatus. The construction of the platform of the bridge presents several novel combinations of wood and iron, and is of extreme stiffness, to resist the violent action of the eddies of air in violent winds, which have so often injured, and even destroyed, the ordinary platforms of suspension bridges in other places. The balustrade is remarkably light and elegant, in ornamental panels of wrought-iron. Indeed, cast-iron has been carefully excluded from every part of the whole bridge, except where its use was really preferable or absolutely unavoidable. The total weight of iron used in the construction of the bridge is about 3,300 tons, including the machinery used in the various stages of its construction. The whole was made in England, several of the most celebrated ironmasters and manufacturers having been engaged upon it. It required fifteen vessels to bring the iron to Odessa, whence it was taken up to Kieff in small wagons drawn by oxen, over the wild steppes, almost without roads, or none that deserve the name.

The quantity of machinery of every kind employed in the construction of the Kieff bridge is most enormous, and not less than nine steam-engines are in use. Two of these are large stationary ones, each capable of working up to a power of 50 horses; the rest are from four to eight horses' power, and can be moved about as required. These engines pump water, drive piles, grind mortar, hoist timber, iron, &c., draw loads, and perform a variety of other operations, in substitution of manual labour.

A temporary bridge, carrying a railway, has been thrown across the whole breadth of the Dnieper, and is connected by a self-acting inclined plane with the heights of Kieff, whence the great blocks of granite and masses of iron are sent down from the depôts above to the works on the river. The great provision of granite, bricks, timber, cement, lime, field-stones, &c., is very extraordinary, covering many acres of ground. A whole village of warehouses, offices, shops, sheds, dwelling-houses for the superintendents, and comfortable cottages for the numerous workmen, have been erected on the left bank of the river, on ground expressly raised for the purpose above the flood level. A regular commissariat is attached to the establishment, and the whole organisation of service is very complete. The bricks employed are very hard, and of a beautiful pale colour. Extensive quarries of granite were opened in a great many places, solely for these works; but the principal supply and the largest and finest blocks are found nearly 100 miles from Kieff, and are brought thither on bullock-carts, through a rough country, destitute of roads. Not the least remarkable part of the establishment is that for the manufacture of the hydraulic cement required for the foundations and masonry. It is, in fact, an artificial puzzolano, made from a peculiar clay found in the Kieff hills, and prepared on the principles laid down by the celebrated French engineer, Vicat, in his recent publication. The buildings for this purpose are very extensive, being gigantic laboratories, where the operations are carried on day and night. Eight large roasting ovens, besides numerous grinding mills, are in constant action; the quantity manufactured is upwards of 300 bushels (or about 500 cubic feet) in every 24 hours.

It must be reserved for a technical publication to enter into all the engineering details of construction of the Kieff bridge, as there can only be given here a merely general idea of the principal features of this magnificent bridge, which will be the largest in Europe, the length being fully half an English mile, and covering an area of 100,000 square feet, being considerably more than three acres. The works were first commenced in April 1848. The ceremony of laying the first stone took place in September of the same year. Eight large cofferdams were completed by the early part of 1849; two of these having been destroyed or damaged by the spring floods, have since been entirely reconstructed. The foundations of the abutments and of two of the river piers were safely got in before the winter began, and all the foundations and cofferdams have been secured by an extensive system of protecting works of *mattrasse-fascines*, laid down according to the modern practice in Holland, by Dutch contractors brought purposely to Kieff by Mr. Vignoles. It is expected that the whole of the masonry will be completed by the end of the season of 1850, and that in the course of the autumn of 1851, the Kieff Suspension bridge will be finished and opened.

The causeway approaching the Dnieper from the northward, as before-mentioned, having been greatly damaged in the great floods of 1845, will be put into sufficient repair for the roads on the left bank of the river. On the right bank, a fine new road along the shore at the foot of the acclivities leads up-stream to the commercial and other parts of Kieff, and down-stream to the present ferry and the lower fortresses. Another road will be formed ascending to the great military positions on the heights above.

The beautiful model of this remarkable bridge is on a scale of about $\frac{1}{100}$ of the length of the actual work. It is the most perfect thing of the kind probably ever designed or executed, and reflects the highest credit on Mr. James, of London, the modeller, and his chief assistant, Mr. Sims, who, with another engineer, came purposely from London to erect the model at St. Petersburgh. Every piece of wood or iron, every bolt, screw, and plank—and they are there by thousands—is represented in miniature and in the most perfect manner; the architectural details of the masonry, the interior arrangements of the abutments, the moorings, and saddles of the chains, the machinery of the swivel bridge—all are faithfully represented on the proper scale, and in due proportion. The proportionate scale of length being as 1 to 100, that of area is of course as 1 to 10,000, and that of cube as 1 to 1,000,000! and all the smaller pieces of iron are accurately put into the model in the latter proportion. The stand for the model is of mahogany, supported on bronze Ionic pillars, with gold capitals and frieze, forming a splendid piece of furniture, worthy even of the Imperial Palace. The water of the Dnieper is represented by a mirror, which reflects the under side of the platform, and the whole model is covered with a splendid glass case, set in a gilt frame, with a beautiful dome of glass, supported on richly gilt pillars of the Corinthian order; the whole exquisitely chased. The model and stand have required two years to make, and the expense, from first to last, has been fully 6,000*l.* sterling.

The cost of the Kieff suspension bridge, exclusive of the approaches, will be upwards of 400,000 guineas—say about two millions and a half of silver roubles of Russia, and nearly 11,000,000fr., which, though large in amount, may be considered a very low price for so large a work. Mr. Vignoles has already prepared, by command of the Emperor, designs for several other large bridges in various parts of Russia. Some of them have been approved, and others are still under consideration, and designs are in various stages of progress for still more bridges, besides other works; for all of which the iron must be furnished from the English manufactories.—*Times.*

REVIEWS.

A Treatise on the Rise and Progress of Decorated Window Tracery in England. By Edmund Sharpe, M.A., Architect. London: Van Voorst, 1849.

If the passion for mediæval works has had no better results, it has had a good one in this, that it has given us a copious literature for the mediæval styles, and has destroyed the monopoly of the Greek and Roman styles. So long as these latter were the only learned styles, their professors could put forward a magistral claim, and assume the air of superiority without allowing dispute; just as the Greek and Latin languages were called learned, when these alone had a philological organisation. It is always a bad thing when people are saved the trouble of thinking for themselves, and become "*Ullius jurare in verba magistri.*" When once they have taken to themselves a master, and swear in his name, they are, like other dogs, faithful to his service, and snap and snarl at everybody else. So was it with our classic architects—the principles of art were set aside, and the Ionic or Doric canon was flourished as a weapon against any unlucky wight who thought anything could be beautiful or sublime without the Grecian stamp.

It is to be hoped we are getting to a better period, when we shall be neither Ionic, Italian, or Christian-ite sectarians, but shall be able to acknowledge and appreciate the beautiful in art, whether in the Indies, Persepolis, Hellas, or Germania; and having got thereby so much nearer to the right shrine and the true worship, we may be inspired to do something of our own. Everyone who has a true love for art has, therefore, a deep interest in the cultivation of every department of it: the architect should make a saying for himself, that there is nothing architectural which does not claim his sympathy; and the writer should be encouraged who gives us practical information not only as to Greek and mediæval art, but as to the productions of Egypt, Persepolis, and Hindostan. Thus, Layard, Fergusson, and Owen Jones are as great benefactors to the cause of art as Wilkin or Pugin. It is very certain that we want all the energies of the human mind to be successful in the noble study of architecture; and nothing can be so surely detrimental as restriction to any one school or school-book, if we are to have a national school of architecture as we have a national school in everything else. There are few now who are contented to be the lacqueys of the Greeks and Normans—and yet such we are; while in every other pursuit of genius, we have shown ourselves not unworthy rivals of the great men of olden and of later time.

To study any department of architecture properly, as much attention must be paid to constructive peculiarities as to artistic effect; and as this requires a practical treatment, it seems to us, suiting so well the English character, the field of architectural exploration is one in which we are likely to be particularly successful. Indeed, however much the High Dutch have dreamed, the English have with pen and pencil truly done their share of work; and in England, Normandy, Flanders, Dutchland, Italy, Greece, Egypt, Lesser Asia, Assyria, Hindostan, and Mexico, our students have done much for the extension of architectural knowledge.

It is not, however, given to every one to wend his way to the great shrines of art; and though railway travelling has extended the resources of architectural study, a scamper to Rome or to Memphis can hardly be looked upon as greatly conducive to the instruction of the mass. If, however, this is not so, we believe, if they are properly used, there are large means of instruction open to every study, even in the remotest parts of this country, if he will but choose them, There is hardly a parish church which has not some point of interest to the practical man; and indeed it is from the careful inspection of these buildings by a practical eye, that a few men, more painstaking than their brethren, have put us in possession of the architectural practice of the middle ages, and have enabled us to construct modern works in the mediæval styles in a much more respectable and much truer manner than our imitations of the Parthenon and other classic models. Nevertheless, a few men can do but little of themselves, however hard they work: it is the concentrated energies of the mass which must act to produce any great result; and this can only be attained inasmuch as each member of the profession will look upon himself as an instrument, however humble, for its advancement. The pupil in the country, beginning his early studies, has often opportunities, denied to the most ardent votaries in the great seats of knowledge; and if he diligently takes advantage of the resources of his neighbourhood, he may do very much good to himself and his neighbours.

There is, too, nothing so mean in itself, which as a part of a great whole, when properly studied, does not acquire considerable importance; and, indeed, often the neglect of a trifle destroys the most meritorious exertions devoted to a great building. In the Gothic revivals of the last century, we are much more struck with pain than with pleasure, for the discordance of the details mars the most ambitious designs,—and this much more attributable to want of constructive knowledge, than to want of artistic skill. As the writer now before us reminds his readers, the history of the mediæval styles in England is one of progress; and the experience of many years, and the genius of many men, led to improvements in construction, as much as to variety in design. These escape the mere archæologist or artist, or he sees them only as trifles, the value of which he does not know; but to the practised eye even of a workman, a knowledge of these trifles is the way to the economical and successful prosecution of a restoration or of a new construction.

It is very evident that had we a better knowledge of the constructive details of Greek buildings, we should be much more successful in the imitation of them; neither would so much diversity of opinion prevail upon many questions of interest, as lights, windows, doors, stairs, roofs, polychromy, and so forth. A knowledge which limits itself to broad general features, might have been thought more favourable to the study of the Greek style; but it has not so proved—and perhaps most from this cause, that the groundwork of our knowledge is imperfect, and imperfect in the practical part. On the other hand, we have monuments which present a repertory of mediæval practice; and it will be found that just in proportion to our better acquaintance with these, has been our successful progress. Wren, Walpole, and Dance had the great works of old before their eyes, and yet the towers of Westminster Abbey, Strawberry Hill, and the front of Guildhall are the fruits of their exertions. The restorations of the beginning of this century abound with errors, and we shall have before us a fresh work —that of re-restoration. Mr. Sharpe gives some examples of this.

The careful study of details has given us works on mouldings, fonts, and church fittings, and now on decorated window tracery. Although the subject is so limited, Mr. Sharpe has required for its illustration a volume of text and one of plates; and even yet he has only laid the foundation of his own part, and leaves for other labourers quite enough to fill other volumes. Nearly two hundred engravings are required, to furnish examples from which authorities are deduced,—and yet the writer is neither prolix nor trifling, nor minutely archæological. He gives a sufficient sketch of the history and chronology, to determine the characteristics of style; but, throughout, his attention is devoted to practical construction. From this the workman will benefit as much as the architect.

Inasmuch as the engineer is often too much of a workman, so is the architect often too little of a workman: and yet there is in this country no academy of architecture with so much as a carpenter's shop attached to it. The architect of the middle ages, inasmuch as he practised all the higher branches of art—carving, painting, and music—so was he often skilful as a blacksmith, mason, or carpenter. The necessities of his position as much made him so, as do those of an Indian officer of engineers make him a workman. In a remote part of the country, the architect had to teach and train the workmen, as well as to furnish the plan. This, too, was one great means of architectural progress. Whoever looks at the buildings of the middle ages, is astonished to see how much was then done. There is hardly a parish church in England which was not then built; and yet in parishes which must then have had a smaller population, we have buildings much more massive and expensive than our modern resources enable us to supply.

The monk or ecclesiastic who undertook to build a church, was much more wanting in money-help than the modern patron; but he drew largely on the unskilled labour of the population. The days of idleness incident to agricultural pursuits, instead of being devoted to the alehouse, were claimed for the pious work of church building; and an enlightened instructor trained a willing flock to undertake the several duties, from quarrying the stone to the carving of it and building it up.

We have now to rely upon trained workmen, instead of upon trained architects; and though we are better off than we were, we are far from having reached perfection. We now look with shame upon the carpenter-Gothic windows of good King George's time—and yet perhaps the day is not far off, when the hypercritical eyes of those who follow may point out the failings of our own works. The only bulwark against this is the practical instruction of architects and workmen. While it is an object of ambition to an architect to produce a beautiful piece of tracery, he is often at the mercy of the workman for the realisation of his designs, for even such a detail requires much knowledge and skill.

If Mr. Sharp has done his duty, so have the publisher and engraver; for the work is handsomely and copiously illustrated throughout, in a manner which is well deserving of praise.

We like much the moderate and judicious spirit in which Mr. Sharpe writes; and he gives full assurance that he merits the confidence of his readers. While he has carefully availed himself of the studies of others, he has added largely to the common stock; and has, by his own observations, been able to correct many theories which were founded on erroneous data. The work has, therefore, the best kind of originality in a professional work—an original investigation of the whole subject of inquiry.

Mr. Sharpe classifies tracery into three styles—geometrical, curvilinear, and rectilinear; and not merely determines the essentials of style, but examines the several arches of the window opening, as the window arch, the scoinson arch, and the rear vault; the foliation; and the mouldings. Upon each of these heads he enters into copious explanations. There is, however, one thing we miss—a sufficient index.

We are debarred from entering further into a subject which is so much matter of special detail, though we are tempted by the merits of the author so to do; but we cannot take leave of him without saying that he has written a book well worthy of the perusal of members of the profession, and of the large circle of students of mediæval architecture, its lay and clerical devotees.

Modern Tombs, Part I. By Arthur W. Hakewill.

Some years since we had occasion to notice a work on tombs, and to make some remarks on this branch of art; and we are not sorry to have it again brought to mind by this work of Mr. Hakewill's. In churches, tombs are most commonly one-sided; and as there is no finished back, there is a limited scope for artistic exertion. If, too, a tomb be truly designed, its character is determined by that of the building; and this is another point of restriction. Where not attended to, as it very seldom is, our cathedrals become curiosity shops or museums, in which naked Greeks and negroes besport beneath the canopies and shrines of mediæval architects. The establishment of the cemeteries threw open a new field for the artist, and one in which he has much more freedom. At the same time the architect could fairly claim a participation, and thus the body of skilled labourers has been strengthened.

It is quite true the marble-mason still claims the graveyard as his domain, and leaves many boundmarks of his authority; but there is a greater disposition on the part of the public to encourage architects; and this it is Mr. Hakewill's object to support. Which, however, will become the chief ruler, the architect or the sculptor, will depend very much on the exertions of each.

While architecture gains a new field of display, it further benefits by the necessity imposed upon sculptors of becoming students of architecture, and strengthening thereby that union of the arts, without the observance of which they cannot prosper. Then, too, the architects must learn something of sculpture, or the public will not be satisfied.

At a former period we were obliged to be contented with designs for tombs, and with the promise of what the future was to do for us; but now we have got some earnest of progress, as Mr. Hakewill's book gives examples from tombs already in our cemeteries. This book, too, will give the greater encouragement to artists, as it shows them what has been done, and that they will not labour in vain. Every way, therefore the book is of interest.

At such an early period we are not to expect perfection—we are to be prepared for many faults; but nevertheless we say that many of the examples presented by Mr. Hakewill deserve consideration and praise. The monument to the prize-fighter, Jackson, by Thomas Butler, in Earl's-Court Cemetery, is very praiseworthy, from the boldness of the design. As to the taste of so openly commemorating such a man, it is nothing to us—we cannot help; and most of the victors at Olympia were of the same stamp. Morrison, the hygeist, St. John Long, the back-scratcher, and Andrew Ducrow, the mountebank, have the largest tombs at Kensal-green: but then they paid for them beforehand, and they had a right to do what they liked with their own. Jackson left a large sum for a tomb; and work of art though it is, and encomiastic as are the verses upon it, it is a monument to a prize-fighter, and nothing else. The lion lying on the top, and the naked prize-fighter at each end, are in keeping; and the prize-fighters are prize-fighters, and nothing else: they are no shams—no model men—no ideals; neither Adonis nor Antinous, but prize-fighters, with the disproportions and characteristics of such. The sculptor knows what such a man is, and has carved him accordingly.

Another design which is in Kensal-green—a tomb with an angel in front—is likewise of a sculptural character, and particularly impressive.

The outline of that of Reynold Morgan, in Kensal-green, is very pleasing. It is a composition with a vase, particularly happy in the harmony of the forms.

We cannot say we like so well some of the architectural designs. They show the old leaven of the sham classical, where the mere introduction of a cornice, or some such feature, in a bald design, is made to do duty for taste and simplicity. The conventionality is purely professional; beauty, under the circumstances, there is none, and the result is the erection of a toy-building instead of a tomb. An Egyptian monument, in which Egyptian peculiarities have been carried too far, pleases us no better; and although it may give an example of the Egyptian style, it gives no favourable proof of the powers of the architect.

The work is to be in four quarterly parts, and to embrace fifty designs; and we very much mistake if Mr. Hakewill will not succeed in giving his readers employment and remuneration, as well as a book, if they take the hint to apply themselves to this branch of practice.

The Pictorial Guide to Ripon. By John Richard Walbran, Local Secretary of the Archæological Institute. Third Edition. London: Nichols and Son, 1850.

Sepulchri, a Romanis Constructi infra Ecclesiam S. Wilfridi in Civitati Riponensii. By W. Downing Bruce, F.S.A., K.C.J. Third Edition. London: Simpkin and Co., 1850.

The Guide-book is interesting both to the antiquary and the architect. It contains a most accurate and entertaining description of the cathedral church of St. Peter, at Ripon, and of the monastic remains of Fountains and Bolton abbeys; likewise an account of the extensive excavations going on at the present time at Fountains (the property of Earl de Grey), under the direction of the author, a well-known antiquary in the north of England,—the research being directed to an hitherto neglected portion of the fabric, the Abbot's house; the result corroborating the assumption of Mr. Walbran, that its site was on the south-east side of the Lady-chapel—in opposition to the received idea that the Zenodochia, on the western side of the cloisters, had been appropriated to this purpose. The whole site of the house has not been excavated, but quite sufficient has been to indicate its extent. The dimensions of the principal apartments are—The great hall, divided into a main and two side aisles by nine columns, 167 ft. 6 in. by 69 ft. 10 in.; the passage leading from the cloister court of the abbey, 15 ft. 7 in. wide; the chief staircase, 6 ft. 7 in. wide; the oratory or chapel (the last portion built), 46 ft. 6 in. by 11 ft. 5 in.; the refectory, 62 ft. by 23 ft. 9 in.; the dais, 11 ft. 3 in. wide. John de Cancia, the abbot, was the builder of the house (1219-47). The character of the building is plain and substantial. The floors of the principal apartments were paved with encaustic square tiles; several patterns are introduced: one of four tiles displays the arms of the abbey, another the lozenge inclosing the rose. The author supposes they were the rejected tiles of some great work which will be hereafter discovered in the abbey.

The object of Mr. Bruce in his pamphlet is to prove a similarity between the famed crypt under the central tower of Ripon cathedral (usually called St. Wilfred's Needle), and Virgil's Tomb, near Naples,—which he proves by giving a plan and section of each. His efforts to connect the two show, at least, that the Saxons had succeeded admirably in imitating the Roman style of architecture. Mr. Walbran has availed himself of Mr. Bruce's researches on this point.

The Banqueting House, Whitehall, designed by Inigo Jones, consisting of an elevation and two sheets of details. By Octavius Hansard, Architect. London: John Weale.

These prints are a valuable acquisition to the architect, and do great credit to the labours of Mr. Hansard; all the measurements of the principal elevation have been taken by him at great cost and labour; he was daily to be seen suspended in a car by a rope taking dimensions of the several details. The plates consist first of an elevation geometrically drawn and shaded to a scale of ¼ of an inch to the foot, and two plates showing all the details drawn to a scale 1½ inch to the foot, together with all the dimensions in figures.

"The peculiarities of the building," Mr. Hansard observes, "are numerous, and, as in most large works, so in this, the dimensions of similar and corresponding portions do not exactly agree; their difference, however, is not perceptible.

"On a comparison of the original drawings by Inigo Jones* with the structure itself, it would appear that at some period the rusticated basement has been altered, probably on the occasion of a repair; indeed, there can be no doubt of the rustication of the basement of the west front having been originally similar to that of the east.

The following are the general dimensions:—

	Ft.	In.	Ft.	In.
Height of Rusticated Basement			10	9⅞
Height of Ionic Column	23	9¾		
Height of Entablature	4	9¾		
Total Height of Inferior Order			28	7½
Height of Blocking Course	1	2		
Height of Composite Column	22	7		
Height of Composite Entablature	4	8⅝		
Total Height of Superior Order			28	5⅝
Height of Balustrade and its Plinths			7	4⅛
Total Height of Building			75	3⅛
Total Length on Plinth Line			121	2¾

* In the Library of Worcester College, Oxford.

Buildings and Monuments, Part V. Edited by G. Godwin, F.S.A.

These illustrations are so well executed and so pleasing, that we regret the series is drawing towards a close; and we hope, therefore, the encouragement Mr. Godwin has already received is such as to induce him hereafter to undertake another work of the same kind. The engravings are pleasing; and as the book has the advantage of illustrations from Mr. Godwin's pen, it has likewise a professional as well as a popular value.

Rudimentary Treatise—Tubular and other Iron Girder Bridges. By S. Drysdale Dempsey. London: Weale.

Mr. Dempsey has in this book brought together all the information extant as to the Britannia and Conway tubular bridges; and those of our readers who have already been put in possession of it piecemeal in our *Journal*, may be glad to have this summary of the subject, in which the text and engravings are reduced to a more portable form.

HUTCHISON'S INDURATED STONE.

Mr. Hutchison has been most successful in rendering the soft sandstone, which abounds at Tunbridge Wells and other parts of Kent, perfectly hard and impervious to wet. Its advantages for many purposes are very great. The stone, when in a soft state in the quarry, is shaped or worked to its proper form, as for chimney-pieces, moldings, ashlar, steps, sinks, &c.; and it afterwards undergoes some preparation which renders it equal to the hardest stone. Mr. Hutchison can deliver the prepared indurated ashlar stone in London, ready for setting, at 1*s.* 6*d.* per foot cube, and 1½ inch rubbed paving at 6*d.* per foot. The paving has been submitted to a severe test for three years at Tunbridge Wells. The preparation may be used with great advantage for any soft stone, and even for chalk or plaster: some specimens of plaster figures that were submitted to our inspection were as hard as a piece of Yorkshire stone.

IRON FOR RAILWAY STRUCTURES.

Report *of the Commissioners appointed to Inquire into the Application of Iron to Railway Structures.*

From the information supplied to us, it appears that the proportions and forms at present employed for iron structures, have been generally derived from numerous and careful experiments, made by subjecting bars of wrought or cast iron of different forms to the action of weights, and thence determining by theory and calculation such principles and rules as would enable these results to be extended and applied to such larger structures and loads as are required in practice. But the experiments were made by dead pressure, and only apply therefore to the action of weights at rest:—On the contrary, from the nature of the railway system the structures employed therein are necessarily exposed to concussions, vibrations, torsions, and momentary pressures of enormous magnitude, produced by the rapid and repeated passage of heavy trains.

These disturbing causes, in smaller degree, have always occurred in structures connected with mill-work or other mechanism. But the effects upon their stability have not been found greater than could be met by increasing the dimensions of the parts without especially inquiring into the exact principles upon which such increase should be made. Thus, we are informed that the dimensions of cast-iron girders, intended for sustaining stationary loads, such as water-tanks and floors, are usually so proportioned that their breaking-weight shall be three times as great as the load they are expected to carry, or in some cases four or five times as great. But when the girders are intended for railway bridges, and therefore subject to much concussion and vibration, greater strength is given to them by altering the above proportions, and making the breaking-weight from six to ten times as great as the load, according to the practice of different engineers. On the other hand, some consider that one-third of the breaking-weight is as safe a load in the latter case as in the former.

As it soon appeared, in the course of our inquiry, that the effects of heavy bodies moving with great velocity upon structures had never been made the subject of direct scientific investigation, and as it also appeared that in the opinion of practical and scientific engineers such an inquiry was highly desirable, our attention was early directed to the devising of experiments for the purpose of elucidating this matter.

The questions to be examined may be arranged under two heads, namely—

1. Whether the substance of metal which has been exposed for a long period to percussions and vibrations, undergoes any change in the arrangement of its particles, by which it becomes weakened?

2. What are the mechanical effects of percussions, and of the passage of heavy bodies in deflecting and fracturing the bars and beams upon which they are made to act?

A great difference of opinion exists among practical men with respect to the first of these questions. Many curious facts have been elicited by us in evidence, which show that pieces of wrought-iron which have been exposed to vibration, such as the axles of railway carriages, the chains of cranes, &c. employed in raising heavy weights, frequently break after long use, and exhibit a peculiar crystalline fracture and loss of tenacity, which is considered by some engineers to be the result of a gradual change produced in the internal structure of the metal by the vibrations. In confirmation of this, various facts are adduced, as, for instance, that if a piece of good fibrous iron have the thread of a screw cut upon one end of it by the usual process of tapping, which is always accompanied by much vibratory action, and if the bar be then broken across, it will be found that the tapped part is a good deal more crystalline than the other portion of the bar. Others contend that this peculiar structure is the result of an original fault in the process of manufacture, and deny this effect of vibration altogether, whilst some allege that the crystalline structure can be imparted to fibrous iron in various ways, as by repeatedly heating a bar red-hot, and plunging it into cold water, or by continually hammering it, when cold, for half an hour or more.

Mr. Brunel, however, thinks the various appearances of the fracture depend much upon the mode in which the iron is broken. The same piece of iron may be made to exhibit a fibrous fracture when broken by a slow heavy blow, and a crystalline fracture when broken by a sharp short blow. Temperature alone has also a decided effect upon the fracture; iron broken in a cold state shows a more crystalline fracture than the same iron warmed a little.

The same effects are by some supposed to be extended to cast-iron.

We have endeavoured to examine this question experimentally in various ways.

A bar of cast-iron, 3 inches square, was placed on supports about 14 feet asunder. A heavy ball was suspended by a wire 18 feet long, from the roof, so as to touch the centre of the side of the bar. By drawing this ball out of the vertical position at right angles to the length of the bar in the manner of a pendulum to any required distance, and suddenly releasing it, it could be made to strike a horizontal blow upon the bar, the magnitude of which could be adjusted at pleasure either by varying the size of the ball or the distance from which it was released. Various bars (some of smaller size than the above) were subjected by means of this apparatus to successions of blows, numbering in most cases as many as 4,000. The magnitude of the blow in each set of experiments being made greater or smaller, as occasion required. The general result obtained was, that when the blow was powerful enough to bend the bars through one-half of their ultimate deflection (that is to say, the deflection which corresponds to their fracture by dead pressure), no bar was able to stand 4,000 of such blows in succession; but all the bars (when sound) resisted the effects of 4,000 blows, each bending them through one-third of their ultimate deflection.

Other cast-iron bars, of similar dimensions, were subjected to the action of a revolving cam, driven by a steam-engine. By this they were quietly depressed in the centre, and allowed to restore themselves, the process being continued to the extent even in some cases of 100,000 successive periodic depressions for each bar, and at a rate of about four per minute. Another contrivance was tried by which the whole bar was also during the depression thrown into a violent tremor. The results of these experiments were, that when the depression was equal to one-third of the ultimate deflection, the bars were not weakened. This was ascertained by breaking them in the usual manner with stationary loads in the centre. When, however, the depressions produced by the machine were made equal to one-half of the ultimate deflection, the bars were actually broken by less than 900 depressions. This result corresponds with and confirms the former.

By other machinery a weight equal to one-half of the breaking-weight was slowly and continually dragged backwards and forwards from one end to the other of a bar of similar dimensions to the above. A sound bar was not apparently weakened by 96,000 transits of the weight.

It may, on the whole, therefore be said, that as far as the effects of reiterated flexure are concerned, cast-iron beams should be so proportioned as scarcely to suffer a deflection of one-third of their ultimate deflection. And as it will presently appear, that the deflection produced by a given load, if laid on the beam at rest, is liable to be considerably increased by the effect of percussion, as well as by motion imparted to the load, it follows, that to allow the greatest load to be one-sixth of the breaking-weight is hardly a sufficient limit for safety even upon the supposition that the beam is perfectly sound.

In wrought-iron bars no very perceptible effect was produced by 10,000 successive deflections by means of a revolving cam, each deflection being due to half the weight which, when applied statically, produced a large permanent flexure.

Under the second head, namely, the inquiry into the mechanical effects of percussions and moving weights, a great number of experiments have been made to illustrate the impact of heavy bodies on beams. From these it appears that bars of cast-iron of the same length and weight struck horizontally by the same ball (by means of the apparatus above described for long-continued impact), offer the same resistance to impact whatever be the form of their transverse section, provided the sectional area be the same. Thus a bar, 6×1½ inches in section, placed on supports about 14 feet asunder, required the same magnitude of blow to break it in the middle, whether it was struck on the broad side or the narrow one, and similar blows were required to break a bar of the same length, the section of which was a square of 3 inches, and therefore of the same sectional area and weight as the first.

Another course of experiments tried with the same apparatus showed, amongst other results, that the deflections of wrought-iron bars produced by the striking ball were nearly as the velocity of impact. The deflections in cast-iron are greater than in proportion to the velocity.

A set of experiments was undertaken to obtain the effects of additional loads spread uniformly over a beam, in increasing its power of bearing impacts from the same ball falling perpendicularly upon it. It was found that beams of cast-iron, loaded to a certain degree with weights spread over their whole length, and so attached to them as not to prevent the flexure of the bar, resisted greater impacts from the same body falling on them than when the beams were unloaded, in the ratio of two to one. The bars in this case were struck in the middle by the same ball falling vertically, through different heights, and the deflections were nearly as the velocity of impact.

We have also carried on a series of experiments to compare the mechanical effect produced by weights passing with more or less velocity over bridges, with their effect when placed at rest upon them. For this purpose, amongst other methods, an apparatus was constructed, by means of which a car loaded at pleasure with various weights was allowed to run down an inclined plane; the iron bars which were the subject of the experiment were fixed horizontally at the bottom of the plane, in such a manner that the loaded car would pass over them with the velocity acquired in its descent. Thus the effects of giving different velocities to the loaded car, in depressing or fracturing the bars, could be observed and compared with the effects of the same loads placed at rest upon the bar.

This apparatus was on a sufficiently large scale to give a practical value to the results: the upper end of the inclined plane was nearly 40 feet above the horizontal portion, and a pair of rails, 3 feet asunder, were laid along its whole length for the guidance of the car, which was capable of being loaded to about 2 tons; the trial bars, 9 feet in length, were laid in continuation of this railway at the horizontal part, and the inclined and horizontal portions of the railway were connected by a gentle curve. Contrivances were adapted to the trial bars, by means of which the deflections produced by the passage of the loaded car were registered; the velocity given to the car was also measured, but that velocity was, of course, limited by the height of the plane, and the greatest that could be obtained was 43 feet per second, or about 30 miles per hour.

A great number of experiments were tried with this apparatus, for the purpose of comparing the effects of different loads and velocities upon bars of various dimensions, and the general result obtained was that the deflection produced by a load passing along the bar was greater than that which was produced by placing the same load at rest upon the middle of the bar, and that this deflection was increased when the velocity was increased. Thus, for example, when the carriage loaded to 1,120 lb. was placed at rest upon a pair of cast-iron bars, 9 feet long, 4 inches broad, and 1½ in. deep, it produced a deflection of $\frac{6}{10}$ths of an inch; but when the carriage was caused to pass over the bars at the rate of 10 miles an hour, the deflection was increased to $\frac{8}{10}$ths, and went on increasing as the velocity was increased, so that at 30 miles per hour the deflection became 1½ inch; that is, more than double the statical deflection.

Since the velocity so greatly increases the effect of a given load in deflecting the bars, it follows that a much less load will break the bar when it passes over it than when it is placed at rest upon it, and, accordingly, in the example above selected, a weight of 4,150 lb. is required to break the bars if applied at rest upon their centres: but a weight of 1,778 lb. is sufficient to produce fracture if passed over them at the rate of 30 miles an hour.

It also appeared that when motion was given to the load, the points of greatest deflection, and, still more, of the greatest strains, did not remain in the centre of the bars, but were removed nearer to the remote extremity of the bar. The bars, when broken by a travelling load, were always fractured at points beyond their centres, and often broken into four or five pieces, thus indicating the great and unusual strains they had been subjected to.

We have endeavoured to discover the laws which connect these results with each other and with practice, and for this purpose a smaller and more delicate apparatus was constructed to examine the phenomena in their simplest form—namely, in the case of a single weight traversing a light elastic bar. For the weight in its passage along the bar deflects it, and thus the path or trajectory of the centre of the weight, instead of being a horizontal straight line as it would be if the bar were perfectly rigid, becomes a curve, the form of which depends upon the relation between the length, elasticity, and inertia of the bar, the magnitude of the weight and the velocity imparted to it. If the form of this curve could be perfectly determined in all cases, the effects of travelling loads upon bars would be known; but unfortunately the problem in question is so intricate that its complete mathematical solution appears to be beyond the present powers of analysis except in the simplest and most elementary case—namely, in which the load is so arranged as to press upon the bar with one point of contact only, or, in other words, the load is considered as a heavy moving point. In practice, on the contrary, a single four-wheeled carriage touches each rail or girder in two points, and a six-wheeled engine with its tender has five or six points in contact on each side. This greatly complicates the problem.

The above smaller apparatus is so arranged as to comply with the simple condition that the load shall press upon one point only of the bar, and is also furnished with a contrivance by which the effects of various proportions of the mass of the bar to that of the load can be examined. From the nature of the problem, it is convenient to consider, in the first place, the forms of the trajectories that are described, and the corresponding deflections of the bar, when the mass of the bar is exceedingly small compared with that of the load.

Having obtained these under different relations of the length of the bridge, its statical deflection, and the velocity of the passing load, we proceed to investigate, in addition, the effect which a greater proportional mass of the bar or bridge has upon the deflections. We have been greatly assisted in this research by a most elaborate and complete analytical investigation by George Stokes, Esq., Fellow of Pembroke College, Cambridge, undertaken at the request of one of the members of the Commission. Unfortunately, the extreme difficulty of the problem has rendered its solution unattainable excepting in the cases in which the mass of the bridge is supposed to be exceedingly small compared with that of the load, and in the opposite case in which the mass of the load is supposed to be small compared with that of the bridge. The examples that occur in practice lie between these two extremes; for in the experiments of the Commission, performed at Portsmouth, with the inclined plane, already described, the weight of the load was from three to ten times that of the bar; but this is a much greater proportion than that which occurs in bridges, partly on account of the necessity for employing in experiments very flexible bars, to render the changes of deflection sufficiently apparent, and partly on account of the great difference of length; for if bars bearing the same ratio of weight to that of the load were employed in experiment, the deflection would become so small as to be scarcely appreciable. This will readily be perceived when it is stated that in a bridge of 33 feet long, a deflection not greater than one-fourth of an inch is usually allowed, which deflection is only $\frac{1}{1440}$th part of its length; whereas in experiment it is necessary to employ deflections of two or more inches. In actual bridges of about 40 feet span, the weight of the engine and tender is very nearly the same as the weight of that half of the bridge over which it passes; and in large bridges the weight of the load is much less than that of the bridge.

Mr. Stokes has shown, that when the inertia of the bridge is supposed small, the trajectories of the load and the corresponding deflection of the bridge depend upon a certain quantity, which he terms β; this quantity varies directly as the square of the length of the bar, and inversely as the product of the central statical deflection (namely, that which would be produced by the load set at rest on the centre of the bridge), and of the square of the velocity with which the load passes over the bridge. When β is small, the increase of deflection due to the velocity of the load becomes very great, so much so that if β be equal to 1·3, the statical deflections are doubled, and are tripled when $\beta = 0·8$; becoming still greater as lesser values of β are taken. On the contrary, greater values of β correspond to small deflections; and it has been shown by our researches that in the cases of real bridges β is rarely less than 14, and is commonly very much greater; and that, consequently, the greatest increase of deflection from velocity would be upon this theory never greater than one-tenth, varying from that to one-hundredth, or less. As β varies directly as the square of the length of the bridge, it is plain that the nine-feet bars of the Portsmouth experiments will correspond to much less values of β than the 20 and 30-feet lengths of actual bridges; while the values of β in the former cases are still further diminished by the greater deflections necessarily employed in experiments, as above explained. It is thus shown that the enormous increase of deflection produced by velocity in the Portsmouth experiments cannot occur with real bridges, since it appears that the phenomena in question are developed to a great extent when the magnitude of the structure is diminished. But these calculations are made upon the supposition that the inertia of the bridge is very small; and experiments made with the small apparatus above-mentioned have shown that while β is less than about unity, the inertia of the bridge tends to diminish the deflection; while, on the other hand, when β is greater than unity (including, of course, all practical cases), the inertia of the bridge tends to increase the deflections, obtained upon the above supposition. Lastly, the total increase of the statical deflection, when the inertia of the bridge is taken into account, will be found much greater for short bridges than for long bridges. Supposing, for example, the mass of the travelling load and of the bridge to be nearly equal, the increase of the statical deflection at the highest velocities for bridges of 20 feet in length and of the ordinary degree of stiffness may be more than one-half; whereas for bridges of 50 feet in length, the increase will not be greater than one-seventh, and will rapidly diminish as greater lengths are taken. But as it has been shown that the increase *cæteris paribus* is diminished by increasing the stiffness of the bridge, we always have it in our power to reduce its amount within safe limits. Hence in estimating the strength of a railway bridge, this increase of the statical deflection must be taken into account, by calculating it from the greatest load which is likely to pass over the bridge, and from the highest possible velocity. It must be remembered, also, that this deflection is liable to be increased by jerks produced by the passage of the train over the joints of the rails.

We also made some experiments by means of the large apparatus, before mentioned, on curved bars, and these bore much greater weights at high velocities than straight bars; but the deflections of these bars were very great, compared with their length. In drawing attention to these experiments, we would remark that, in actual structures, where the deflections are so very small, the effect of cambering the girders, or of forming a curved pathway for the load, would be of less comparative importance, and might tend to introduce practical inconvenience.

The general impression amongst engineers appears to be at variance with the above results. They, for the most part, state their belief that the deflection caused by passing a weight at a high velocity over a girder is less than the deflection which would be produced by the same weight at rest; even when they have observed an increase, they have attributed it solely to the jerks of the engine or train produced by passing over inequalities at the junction of the rails, or other similar causes.

For the purpose of examining this question, we have submitted two actual bridges to the test of experiment. These bridges, one of which, the Ewell Bridge, is situated upon the Croydon and Epsom line, and the other, the Godstone Bridge, upon the South Eastern line, are both constructed to carry the railway over a road. A scaffold was constructed, which rested on the road, and was, therefore, unaffected by the motion of the bridge, and a pencil was fixed to the under side of one of the girders of the bridge, so that when the latter was deflected by the weight of the engine or train either placed at rest or passing over it, the pencil traced the extent of deflection upon a drawing-board attached to the scaffold. An engine and tender, which had been in each case liberally placed under our orders by the directors of the companies, was made to traverse the bridges at different velocities, or rest upon them at pleasure. The span of the Ewell Bridge is 48 feet, and the statical deflection due to the above load rather more than one-fifth of an inch. This was slightly but decidedly increased when the engine was made to pass over the bridge, and at a velocity of about 50 miles per hour, an increase of one-seventh was observed. As it is known that the strain upon a girder is nearly proportional to the deflection, it must be inferred that in this case the velocity of the load enabled it to exercise the same pressure as if it had been increased by one-seventh, and placed at rest upon the centre of the bridge. The weight of the engine and tender was 39 tons, and the velocity enabled it to exercise a pressure upon the girder equal to a weight of about 45 tons. Similar results were obtained from the Godstone Bridge. We would take this opportunity of mentioning how much we are indebted to Mr. P. W. Barlow and to Mr. Hood for the assistance they afforded us in making these experiments.

We have also to express our obligations to the Astronomer Royal for the advantage of his presence during the above and other experiments, as well as for many valuable suggestions during the progress of the inquiry.

In addition to the above experiments, we have made many for the purpose of supplying data for completing the mechanical theory of elastic beams. If a beam be in any manner bent, its concave side will be compressed, and its convex side extended. An exact knowledge of the laws which govern its compression and extension must precede any accurate general theory of its deflections, vibrations, and ruptures.

The law which is usually assumed in mathematical investigations, and by which the longitudinal compressions and extensions, within certain limits, are assumed to be directly proportional to the forces by which they are produced, although very nearly true in some bodies, is not, perhaps, accurately true for any material.

Experiments have, therefore, been made to determine with precision the direct longitudinal extension and compression of long bars of cast and wrought iron. The extensions were determined by attaching a bar, 50 feet in length and 1 inch square, to the roof of a lofty building, and suspending weights to its lower extremity.

The compressions were ascertained by enclosing a bar 10 feet long and 1 inch square in a groove, placed in a cast-iron frame, which allowed the bar to slide freely without friction, and yet permitted no lateral flexure. The bar was then compressed by means of a lever, loaded with various weights. Every possible precaution was taken to ensure accuracy. The following formulæ were deduced for expressing the relation between the extension and compression of a bar of cast-iron, 10 feet long and 1 inch square, and the weights producing them respectively:—

$$\text{Extension,} \quad w = 116117e - 201905e^2$$

$$\text{Compression,} \quad w = 107763d - 36318d^2.$$

Where w is the weight in pounds acting upon the bar, e the extension and d the compression in inches.

And the formulæ deduced from these, for a bar 1 inch square and of any length, are—

$$\text{For Extension,} \quad w = 13934040\,\frac{e}{l} - 2907432000\,\frac{e^2}{l^2}.$$

$$\text{For Compression,} \quad w = 12931560\,\frac{d}{l} - 522979200\,\frac{d^2}{l^2}.$$

Where l is the length of the bar in inches.

These formulæ were obtained from the mean results of four kinds of cast-iron.

The mean tensile strength of cast-iron derived from these experiments is 15,711 lb. per square inch, and the ultimate extension $\frac{1}{600}$ of the length, and this weight would compress a bar of iron of the same section $\frac{1}{774}$ of its length. It must be observed, that the usual law is very nearly true for wrought-iron.

Many denominations of cast-iron have got into common use, of which the properties had not yet been ascertained with due precision. Seventeen kinds of them have been selected, and their tensile and crushing forces determined. Experiments have also been made upon the transverse strength and resistance of bars of wrought and cast iron acted upon by horizontal as well as vertical forces. These experiments will be found to exhibit very fully the deflections and sets of cast-iron and the defect of its elasticity.

The bars which were experimented upon by transverse pressure, were of sections varying from 1 inch square to 3 inches square, and of various other sections, and the actual breaking weights show that the strength of a bar 1 inch square should not be taken as the unit for calculating the strength of a larger casting of similar metal, although the practice of doing so has been a prevalent one, for it appears that the crystals in the portion of the bar which cools first, are small and close, whilst the central portion of bars 2 inches square, and 3 inches square, is composed of comparatively large crystals, and bars of 3 inches square in section planed down on all sides alike to ¾ of an inch square, are found to be very weak to resist both transverse and crushing pressure. Hence it appears desirable in seeking for a unit for the strength of iron of which a large casting is to be made, that the bar used should equal in thickness the thickest part of the proposed casting.

The performance of these various experiments has been greatly facilitated by the permission which was liberally granted to us by the Lords Commissioners of the Admiralty, to make use of Portsmouth Dockyard in carrying on our investigations, in addition to which, however, we found it necessary to hire for several months some premises in Lambeth. This was found requisite for the performance of those portions of the experimental inquiry which had been undertaken by Eaton Hodgkinson, Esq. Although we are aware that, to point out the labours of individual members of the Commission would be impossible, and that it may appear invidious to single one out for praise, we cannot resist the expression of our thanks to the above-named gentleman for the zeal and intelligence with which he has carried out the remarkable series of experiments which are detailed in the Appendix to this Report, and which constitute a large proportion of those which have been already described.

In addition we have obtained, from many of the iron-masters, information respecting the various processes employed by them in the manufacture of their irons, and the effect of such processes upon the strength and properties of the material produced: and we have also made careful inquiries of civil engineers with respect to the qualities and mixtures of iron preferred by them, for the large castings used in the construction of railway bridges, and to the respective properties of hot-blast and cold-blast iron: this investigation has been greatly facilitated by the liberality and candour with which these gentlemen have communicated to us the results of their experience.

As no map of the kingdom had been constructed representing the districts in which iron is found and worked, we applied to the officers of the Museum of Practical Geology for their assistance, and they caused one to be prepared expressly to accompany this Report, in which the principal furnaces now in blast are shown.

Great differences of opinion exist with respect to the best qualities and mixtures of iron; and, after all, it appears that those employed for large castings depend practically so much upon the commercial question of relative cost that engineers are rarely able to select the very best material. It is generally admitted that engineers have no guarantee that the mixture for which they have stipulated in a contract shall be that used by the founder, and no certain test by which to determine whether a given piece of iron has been manufactured by hot or cold blast. A very good protection appears to be contained in the recommendation of Mr. Fox, that engineers in contracting for a number of girders, should stipulate that they should not break with less than a certain weight (leaving the mixture to the founder), and cause one more than the required number to be cast. The engineer may then select one to be broken, and, if it break with less weight than that agreed upon, the whole may be rejected.

At the beginning of the railway system the bridges were naturally constructed upon similar principles to those which had been already employed for common roads or aqueducts. Some of these ordinary constructions have proved inadequate to sustain the enormous loads and vibrations of railway trains. Some have been considered too expensive; others, as the suspension bridges, have been found wholly unfitted for railway purposes. Moreover, the necessity for preserving the level of a railroad as much as possible, combined with that of passing under or over existing canals, rivers, or roads, has created a demand for those forms of bridges which admit of being kept as low as possible, consistently with the proper headway or passage below; or, in other words, of making the least possible difference of level between the road or stream which the bridge has to carry and that which it has to cross.

From these causes, combined with the innumerable opportunities of building new bridges which the railways have given occasion to, and a constant endeavour to reduce the expense of building them, a variety of new constructions have been proposed and essayed, most of them of great merit and value, while others appear to be of very doubtful stability.

On the whole, the art of railway bridge-building cannot be said to be in that settled state which would enable an engineer to apply principles with confidence. We have therefore thought it our duty to inquire into the present methods of railway bridge-building, to collect in evidence the opinions and practice of the leading members of the profession of civil engineers upon this branch of construction, and especially with respect to the form and proportions of simple cast-iron girders, the practical limits to the employment of such girders, the methods of combining them with the rest of the structure, the various forms of compound girders, the expediency of several combinations of wrought-iron with cast-iron: and, finally, the comparative merits of plain girders, and of other forms in which the principles of the arch, or other methods of giving stiffness, are introduced.

The simplest bridge, and that which admits of the greatest possible headway at a given elevation, is, undoubtedly, the straight girder bridge.

The length of a simple cast-iron girder appears to be limited only by the power of making sound castings, and the difficulty of moving large masses. Thus the practical length has been variously stated to us as 40, 50, and 60 feet. The form resulting from Mr. Hodgkinson's former experiments on this subject is universally admitted to be that which gives the greatest strength; but the requirements of construction compel many variatians from it, especially in the ratio between the top and bottom flanges. Moreover the convenience and the necessity of keeping the roadway for rails as low as possible has introduced a practice of supporting the beams which sustain the rails upon one side of the bottom flange. The pressure of the roadway and of the passing loads being thus thrown wholly on one side of the central vertical web of the girder produces torsion (which is not always taken into account in determining the proportions of the girder). The existence of this torsion is admitted on all hands, and various schemes are employed to counteract and diminish it; but the form of a girder that will effectually resist this disturbing force, without incurring other evils, still remains a desideratum.

The requisite length of girders is increased considerably by the excessive use of skew bridges; and it is much to be regretted that difficulties should often be thrown in the way of altering the course of existing roads and canals when the line of a proposed railway happens to cross them at an acute angle. Partly from these causes, and partly from a little indulgence in the pride of construction, skew bridges may be found, of which, from the obliquity of the bridge, the girders are more than double the length that would be required by the direct span of the opening to be crossed.

When the span of the opening or other circumstances render the use of single straight girders unadvisable, straight girders built up of several separate castings bolted together, and sometimes trussed with wrought-iron tension rods, are largely employed, and necessarily with great varieties of construction. By these means the girders may be extended to spans of upwards of 120 feet.

When wrought-iron is combined with cast-iron in the manner of trussing, several difficulties arise from the different expansions of the two metals and the difference of their masses, which causes the wrought-iron rods to be more rapidly affected by a sudden change of temperature than the cast-iron parts. The constant strain upon the wrought-iron tends to produce a permanent elongation, and hence tension-rods may require to be occasionally screwed up. We have sought for opinions and information upon all these questions, and these show that the greatest skill and caution are necessary to insure the safe employment of such combinations. It is not admitted that the vibration of railway trains would loosen or injure the bolts or rivets of compound girders. Nevertheless, wood, felt, or other similar substances have occasionally been introduced between surfaces to diminish the communication of vibration.

The general opinion of engineers appears to be that the cast-iron arch is the best form for an iron bridge when it can be selected without regard to expense or to the height above the river or road which is to be crossed. For low bridges the bowstring girder is recommended. Lattice bridges appear to be of doubtful merit.

The latest mode of construction that has been introduced consists of boiler plates riveted together as in iron ship-building, and combined in various ways with cast-iron. Hollow girders are thus formed, which are either made so large as to admit of the road and carriages passing through them, as in the Conway and Britannia bridges, or else these tube girders are made on a smaller scale and employed in the same manner as the ordinary cast-iron girders, to sustain transverse joists which carry the road. The first kind is applicable to enormous spans, those of the two bridges above mentioned being 400 and 462 feet respectively. The second kind are said to be cheaper and more elastic than other forms for spans that exceed 40 feet. These methods appear to possess and to promise many advantages, but they are of such recent introduction that no experience has yet been acquired of their powers to resist the various actions of sudden changes of temperature, vibrations, and other causes of deterioration. We have thought it our duty to seek for information with respect to them, and we find engineers to be for the most part exceedingly favourable towards them; but for the reasons above stated we are unable to express any opinion upon them. At the same time we desire to bear testimony to the patient care and scientific manner in which the forms and proportions of the great tubes of the Conway and Britannia bridges have been elaborated; and we must beg to refer to the Minutes of Evidence for the details of the information which we have collected.

The investigation in which we have been concerned has made it evident that the novelty of the railway system has introduced a variety of new mechanical causes, the effects of which have not yet had time fully to develope themselves, on account of the extent and number of new railways, and the rapidity with which they were constructed, in many cases scarcely giving breathing time to the engineers, by which to observe and profit by the experience of each successive new construction. Thus it has happened that some portions of mechanism and structure have been made too weak, or placed in unfavourable combinations; and hence some unavoidable but most lamentable, and sometimes fatal accidents, have been occasioned. It also appears that there exists a great want of uniformity in practice in many most important matters relating to railway engineering, which shows how imperfect and deficient it yet is in leading principles.

But we have also observed throughout the present inquiry that the engineers have been already warned by experience of the necessity for increasing the strength of bridges employed in railways; and of watching more narrowly their construction, so as to render them as strong as possible. Accordingly we have found that the original structure of all those bridges which had shown the least signs of weakness, has been carefully altered and strengthened, so as to leave no apparent cause for apprehension; while in new bridges, better and stronger combinations are adopted.

And in conclusion, considering that the attention of engineers has been sufficiently awakened to the necessity of providing a superabundant strength in railway structures, and also considering the great importance of leaving the genius of scientific men unfettered for the development of a subject as yet so novel and so rapidly progressive as the construction of railways, we are of opinion that any legislative enactments with respect to the forms and proportions of the iron structures employed therein would be highly inexpedient.

We would, however, direct attention to the general conclusions we have arrived at from our own experiments and from the information supplied to us, namely,—

That it appears advisable for engineers in contracting for castings to stipulate for iron to bear a certain weight instead of endeavouring to procure a specified mixture.

That to calculate the strength of a particular iron for large castings the bars used as a unit should be equal in thickness to the thickest part of the proposed casting.

That, as it has been shown that to resist the effects of reiterated flexure iron should scarcely be allowed to suffer a deflection equal to one-third of its ultimate deflection, and since the deflection produced by a given load is increased by the effects of percussion, it is advisable that the greatest load in railway bridges should in no case exceed one-sixth of the weight which would break the beam when laid on at rest in the centre.

That as it has appeared that the effect of velocity communicated to a load is to increase the deflection that it would produce if set at rest upon the bridge; also that the dynamical increase in bridges of less than 40 feet in length is of sufficient importance to demand attention, and may even for lengths of 20 feet become more than one-half of the statical deflection at high velocities, but can be diminished by increasing the stiffness of the bridge; it is advisable that, for short bridges especially, the increased deflection should be calculated from the greatest load and highest velocity to which the bridge may be liable; and that a weight which would statically produce the same deflection should, in estimating the strength of the structure, be considered as the greatest load to which the bridge is subject.

Lastly, the power of a beam to resist impact varies with the mass of the beam, the striking body being the same, and by increasing the inertia of the beam without adding to its strength the power to resist impact is within certain limits also increased. Hence it follows that weight is an important consideration in structures exposed to concussions.

Whilst, however, we lament that the limited means which have been placed at our disposal, and the great time required for such investigations, have compelled us to leave in an imperfect state, or even to neglect altogether, many interesting and important branches of experimental inquiry, we trust that the facts and opinions which we have been enabled to collect will serve to illustrate the action which takes place under varying circumstances in iron railway bridges, and enable the engineer and mechanic to apply the metal with more confidence than heretofore.

Whitehall, *26th July*, 1849.

WROTTESLEY.
ROBERT WILLIS.
HENRY JAMES.
GEORGE RENNIE.
W. CUBITT.
EATON HODGKINSON.

DOUGLAS GALTON,
Lieut. Royal Engineers,
Secretary.

Analysis of the Evidence received by the Commission.

Chemical Constituents of Iron.—Mr. Morries Stirling states, that iron in its pure state is malleable, and that it is a combination of carbon with iron which produces cast-iron. In addition to carbon, the cast-iron in this country contains silica, lime, magnesia, alumina, occasionally some of the phosphates and other admixtures; but iron made from magnetic ores is much purer. The strength of cast-iron depends upon its freedom from impurities and upon the proportion of carbon it contains. The strongest cast-iron contains about three per cent. of carbon, or, according to Mr. Charles May, when the carbon is in the smallest proportion that produces fluidity, a larger proportion tends to make the iron soft and weak, and a smaller hard and brittle. Mr. Glynn states, that the strongest iron generally shows a clear grey, or slightly mottled fracture, and he considers that that colour indicates the combination of carbon with iron which produces the greatest strength. Mr. Morries Stirling states, that while colour is admissible as a test of strength it is not so of chemical constitution, for though dark-coloured iron is usually weak, grey iron usually strong, and white iron usually brittle, yet black iron when chilled becomes white, although it must be supposed to contain the same quantity of carbon; hence, as a general rule, he concludes that colour indicates the treatment to which iron has been subjected, and in some cases only the quantity of carbon. Mr. Charles May coincides in considering the question of strength to be very much reducible to the quantity of carbon contained in the iron, as some of the tenderest iron skilfully treated will produce some of the strongest castings. Mr. Stephenson and Mr. Morries Stirling mention that the fluidity of the Berlin iron is due to the presence of arsenic, and the latter has observed that manganese mixed artificially with cast-iron closes the grain and is an improvement both to cast-iron and steel. On wrought-iron the effect of manganese is stated to be to give it the hot short property, whilst the cold short is produced by the presence of a small quantity of phosphorus; and the admixture of arsenic renders wrought-iron hard and brittle.

Qualities and Mixtures of Iron.—The use of the *hot-blast* in the manufacture of iron, it is stated by Mr. Glynn, does not of itself make iron worse or better; but by its means, materials, otherwise intractable, yielding alloys of iron may be smelted, instead of ores yielding purer metal. Mr. Morries Stirling has not found any distinct difference between the chemical constituents of hot-blast and cold-blast iron, but apparently there is more carbon in the hot-blast iron, and graphite is more commonly to be seen on the surface of No. 1 hot-blast than on cold-blast iron. Mr. Charles May considers, that by the use of the hot-blast the quantity of carbon which can be combined with the iron is increased. Mr. Hawkshaw and Mr. Fairbairn consider hot-blast iron weaker than cold-blast; the latter gentleman and Mr. Stephenson state that the use of the hot-blast renders the metal very fluid; and Mr. Glynn says that its use is to produce in large quantities and at a cheap rate a soft fluid metal to be employed in light castings, and that in that respect he considers the invention to be of great public benefit, as enabling Scotch iron-masters to use a new kind of ore, which though of a weaker character, further experience may enable them to purify and improve.

At the same time the hot-blast is essential for smelting the iron-stone from South Wales with anthracite coal, and the metal yielded is of the strongest character. Mr. Glynn and Mr. Stephenson mention that generally hot-blast iron is dark grey in colour and very fine in the crystal; but it appears to be universally agreed that there is no certain method of distinguishing hot-blast from cold-blast iron. Mr. Rastrick states that the temperature of the hot-blast at the Gartsherrie furnaces was 680° Fahrenheit.

Mr. Stephenson does not attach much importance to the variation in strength of different sorts of iron, he considers that taking the average of irons generally throughout the country there is a proximity to an uniform standard. He concludes, from a series of experiments made by him for the High Level Bridge at Newcastle, that hot-blast iron is less certain in its results than cold-blast; that mixtures of cold-blast are more uniform than those of hot-blast; that mixtures of hot and cold-blast give the best results; that simple samples do not run so solid as mixtures; that simple samples run too hard and sometimes too soft for practical purposes. Mr. Rastrick would prefer making girders of forge iron. Mr. Hawkshaw would use the Lowmoor iron. It is, however, generally admitted that mixing irons from different parts of the country produces the best castings, and since the object in mixing them is to obtain the proportion of carbon to iron which gives the greatest strength combined with the required degree of fluidity, the exact proportion will be regulated by the appearance of the fracture of the several irons. Mr. Morries Stirling states that No. 1, hot-blast iron, mixed with No. 3, cold-blast, will give the right proportion of carbon; but that if iron containing that proportion could be obtained at once from the blast-furnace, it would be very superior. Mr. Charles May, however, observes, that the strength of cast-iron depends upon the bulk into which it is to be run as well as upon its constituent parts, and that the art of the ironfounder consists in his ability to produce the required amount of strength without any very definite knowledge upon the subject, either chemical or mechanical. Mr. Fox considers a very good mixture for girders to be cold-blast Blaenavon, two-thirds, and of hot-blast Scotch two sorts, from the black band and the red hæmatite ores, one-third. Mr. Grissell considers the use of old scrap iron to be of immense value, and would use Scotch iron, cold-blast Welch, and old scrap. Mr. Fairbairn names as the best mixture independently of price—

Lowmoor, No. 3	30	per cent.
Blaina, or Yorkshire, No. 2. . .	25	„
Shropshire, or Derbyshire, No. 3 .	25	„
Good Old Scrap	20	„
	100	

Mr. Glynn names one-third strong iron from South Wales and two-thirds of the more fluid metal of Yorkshire, Derbyshire, and Shropshire. Mr. C. Fox, Mr. Grissell, and Mr. Charles May, however, all concur in stating that mixtures of iron practically depend very much upon the commercial question of cost, and it is generally admitted that engineers have no guarantee that the mixture for which they may have stipulated in a contract shall be that used by the founder; hence Mr. Fox recommends that engineers in contracting for a number of girders should stipulate that they should not break with less than a certain weight (leaving the mixture to the founder), and cause one more than the required number to be cast; the engineer might then select any one to be broken, and if it broke with a less weight than had been agreed upon, the whole should be rejected. Mr. Glynn considers that the strongest castings are those cast from the air-furnace in dry sand, and castings in loam are stronger than those in open sand. The metal is more dense and more free from impurity when cast upright. Mr. Fox and Mr. Fairbairn also prefer the air-furnace. With respect to wrought-iron, Mr. Morries Stirling considers the process adapted in its manufacture as capable of great improvement. Mr. E. Clarke states, that wrought-iron from the same maker is not always the same, and though there is not much difference in the ultimate strength of iron, that some qualities extend much more than others before breaking.

Proportion of Load to Breaking Weight, in Girders.—There appears to be a considerable difference of opinion as to the proportion between the greatest load which a girder should be allowed to bear and the breaking weight. There are two conditions under which the weight may be applied, viz., first, when stationary, as in the case of water-tanks, floors, &c.; second, when the weight moves so as to cause concussions and vibrations, as in railway bridges. In girders required for the first case Mr. Fox and Mr. T. Cubitt consider that the breaking weight should be three times the greatest load; Mr. P. W. Barlow four times; and Mr. Glynn would not make it less than five times the load.

In girders for railway bridges Mr. Brunel states that he allows the load to be one-third or two-fifths of the breaking weight; but he considers that the rule he adopts for calculating the dimensions of his girders gives more than the usual strength. Mr. Grissell and Mr. Charles May consider one-third to be sufficient; Mr. Rastrick, Mr. P. W. Barlow, Mr. R. Stephenson, and Mr. Joseph Cubitt adopt one-sixth; Mr. Hawkshaw prefers one-seventh, except in cases where great care is exercised in the selection of materials and workmanship, when a smaller proportion would suffice; and Mr. Glynn considers that in structures exposed to concussion and vibration the ultimate strength of a girder should be ten times the greatest load.

Tests for Girders.—The general opinion as to the amount of test which should be applied to girders is that the test should amount to twice the greatest load. Mr. Joseph Cubitt would employ three times the greatest load, or half the breaking weight; and Mr. Thomas Cubitt considers it safer to test a girder almost to the extent that would break it than not to prove it at all, as the testing of girders is the only means of discovering defects under the surface, and concealed from the eye. Mr. Brunel, however, thinks that a girder should not be tested with a weight exceeding the greatest load, as the object in testing is to ascertain the soundness of the casting, which may be judged of by its appearance under the load, and all risk of permanent injury should be carefully avoided. Mr. Rastrick, Mr. Glynn, and Mr. Joseph Cubitt recommend that blows be applied to cast-iron girders when under the testing load. Mr. Hawkshaw and Mr. P. W. Barlow consider that where actual weight is used sufficient vibration is given to the beam by throwing the weight into the scales used in testing. It is stated that, for convenience sake, girders are usually tested by means of the hydraulic press; but Mr. Fairbairn, Mr. Locke, Mr. Brunel, Mr. Joseph Cubitt, and Mr. Fox prefer using actual weight, on account of the uncertainty as to the actual pressure the hydraulic press brings upon the girder; though the latter gentleman considers that all liability to error in the press is obviated by an improved construction which he has adopted. Mr. C. May states that, as girders are bought at the lowest possible price per ton, the manufacturer is compelled to adopt the most convenient and not the best mode for testing them, or ten times his profit would not pay him for the experiment.

Loads on the Bottom Flange.—It is admitted that the mode of supporting the roadway on the bottom flange of a girder causes torsion in the girder, though Mr. Rastrick and Mr. Locke do not consider that the strength is diminished by the pressure being so applied; and Mr. Stephenson does not think the torsion is of sufficient consequence to be noticed. In order to guard against any ill effects which might arise from the torsion, Mr. Locke fits in transverse pieces of timber between the two girders which support a line of rails, chocked perfectly tight, and he ties the bottom webs together with tension bars. Mr. Fairbairn and Mr. Hawkshaw consider it would be advantageous to alter the form of girders to enable them to withstand the torsion. Mr. Fairbairn thinks the cross beams should either lay on the top flange, or be suspended by hook bolts from the bottom flange, in which opinion Mr. Glynn concurs. Mr. Hawkshaw would increase the top flange of the girder, or would cast shoes or brackets on them to bring the bearing of the transverse joists close to the vertical web. Mr. P. W. Barlow has adopted a new form of bridge to avoid this torsion. Mr. W. H. Barlow observed considerable torsion in a girder without any top flange. Mr. Fairbairn and Mr. Hawkshaw are of opinion that wooden cross-bearers for the roadway are liable to increase the amount of torsion by bending; but Mr. Stephenson and Mr. Brunel state that wood is desirable as a cushion to prevent the noise and vibration which iron on iron would be subject to.

Length for Simple Cast-Iron Girders.—The use of simple cast-iron girders in bridges appears to be limited only by the power to make sound castings (which arises chiefly from the difficulty of pouring the metal equally, and the inconvenience of handling large masses. Mr. Rastrick, however, would not put any limit to the length. Mr. Hawkshaw considers that they may safely be made more than 50 feet long; in which opinion Mr. Fox and Mr. Grissell concur, but name 60 feet as the limit. Mr. Glynn, Mr. Charles May, and Mr. Joseph Cubitt would make them from 40 to 50 feet. Mr. P. W. Barlow, Mr. Fairbairn, Mr. W. H. Barlow, and Mr. Stephenson state 40 feet as the limit; and Mr. Brunel names 35 feet, as he does not consider that sound castings can be ensured to a greater length. Mr. Fairbairn, however, mentions a girder in Holland 70 feet long cast in one piece.

Form for Simple Girders.—It appears to be universally admitted that the form resulting from Mr. Hodgkinson's experiments on the tension and compression of iron is that which gives the greatest strength; but the actual proportions are generally modified to suit the varying circumstances under which girders are employed. Mr. Stephenson sometimes makes the top flange equal to the bottom one, but usually in the proportion of 3 : 5, partly to obviate any risk from unequal cooling of the materials, and partly from the necessity of having a large top flange to bolt the flooring to. In preference to using a single girder, Mr. Stephenson recommends two girders to be bolted together, with a baulk of timber between, to which the rail is fixed. Mr. Hawkshaw, Mr. Fox, and Mr. Joseph Cubitt recommend that the top flange be increased beyond the proportions given by Mr. Hodgkinson, in order to resist the lateral torsion. Mr. W. H. Barlow and Mr. Locke would use the arched form of girder whenever practicable, and the former gentleman says that straight girders have been in fashion, and consequently more used than practice actually required. Mr. Fox, in girders subject to dead weight only, would make the proportion of the top flange to the bottom one as 1 : 6; but in railway bridges he recommends 1 : 4. Mr. Thomas Cubitt mentions that shoes, or sockets, or any projections cast on girders, have a tendency to create flaws from causing the dirt to accumulate in those places, and he considers that the shape which will ensure a sound casting should be as much considered as the theoretical form of greatest strength.

Deflection of Girders, and Effects of Permanent Loads and Change of Temperature.—It is considered that girders should not deflect more than from $\frac{1}{800}$th to $\frac{1}{400}$th of their length according to the form of the girder. It does not appear from the evidence that a weight equal to what a girder is constructed to carry will, even if left on for any length of time, cause the deflection of the girder to increase, unless subjected at the same time to considerable changes of temperature. Some experiments made by Mr. Fairbairn and Mr. Braidwood show that iron loses a considerable proportion of its strength when heated to a temperature of more than 220° Fahrenheit, and that it becomes uncertain below 32°. Mr. Clarke described the effect of the sun coming out and shining on the Conway tubular bridge for half an hour to have been to raise the tube vertically one inch; and he mentions that at night, from the low temperature, the deflection was always greater than in the day-time. Mr. Fox instances the effect of frequent and great changes of temperature on some short girders, 6 feet long, which support the hoods of the forges in his workshops. In the day-time they are so warm that the hand can only just bear the heat; at night they become cold. The effect is to make the girders *swag*, and the swagging appears to be continually increasing. Some have attained as much as 3″ deflection in the centre; but their strength does not seem to be impaired.

The general impression of engineers appears to be that the deflection caused by passing a weight at a high velocity over a girder is less than the deflection which would be produced by the same weight at rest; and the increase observed, in many instances, is attributed by Mr. Locke, Mr. Stephenson, and Mr. Fox, to the inequalities at the junction of the rails, or to the jerks of the engine. Mr. Hawkshaw however considers, that the deflections would be increased, and has given some examples of a manifest increase.

Mr. P. W. Barlow has observed a slight increase, and Mr. W. H. Barlow, in reference to this subject, cites a curious phenomenon which he observed on a timber viaduct, viz.: that with a heavy goods train at a low velocity, a certain amount of deflection was produced; but an express train passing immediately afterwards, with a much lighter engine, seemed to push the bridge like a wave before it.

Forms of Girders beyond the limits of simple Cast-Iron Girders.—The modes of construction which have been adopted by engineers for crossing spans beyond the limits of girders made of a single casting, are very various; but the chief forms which have been adopted by engineers for girders of a compound nature in railway bridges may be classed under straight built-girders of cast-iron in separate pieces bolted together; arched girders of cast-iron; trussed girders; bow-string girders; wrought-iron box and tubular girders.

The Built Girder is formed of separate castings fitted closely at the joints and bolted together, and is entirely dependent upon the bolts for support. Mr. Grissell instances one of 120 feet span, and states that he should have no hesitation in making one of 200 feet span; but the engineers generally seemed to consider that other modes of construction disposed the material more advantageously. Mr. P. W. Barlow exhibited a new form of girder in separate castings, for moderate spans.

The Arched Girder.—The cast-iron arch is a mode of construction which all engineers concur in approving of, when not limited by considerations of levels or of abutments. Mr. Locke states he would never willingly use cast-iron in any other shape than that of an arch. Mr. W. H. Barlow has also adopted it where practicable.

The Trussed Girder is straight and of separate castings bolted together, assisted by wrought-iron tension rods. The Dee Bridge girder was on this principle. Mr. Stephenson caused an experimental girder to be made, to exhibit the effect produced by the tension rods, adjusted as they were in the Dee Bridge girders, as well as the effect when adjusted to lie parallel with the bottom flange and adjoining it; these experiments, in conjunction with some made by Mr. T. L. Gooch, show that the tension-rods, though they do not, when acting at the angle, as they did in the Dee Bridge girders, produce the full effect; yet, that they add considerably to the strength of the girder. Mr. Rastrick and Mr. Fairbairn object to the trussed girder on account of the different rates of expansion in cast and wrought-iron. Mr. Stephenson and Mr. Wild propose to obviate this objection by putting the tension-rod along the bottom flange, and applying to it an initial strain of five or six tons per square inch, so as to cause the wrought-iron to come into play as soon as any weight is applied to the girder. Mr. Fox approves of this arrangement, but he considers that a strain upon wrought-iron tends to stretch the metal permanently, and that the tension-rods would require to be tightened periodically, whilst Mr. Stephenson and Mr. Wild have concluded from their experiments, that with a less weight than ten tons per square inch, the elasticity of the metal is not affected. The measure of the strain upon the tension rods is the amount they are actually elongated by screwing up. As a combination of wrought and cast-iron, Mr. P. W. Barlow has proposed to cast a bar of wrought-iron in the bottom flange of a girder, and not to make the bottom flange so large. Mr. Locke, Mr. Stephenson, and Mr. C. May, considered that the different rates of expansion of the two metals would be an objection to it. Mr. Brunel objects to the use of cast-iron in long spans, and its combination with wrought-iron, and prefers a framing of wrought-iron and wood.

Bowstring Girder.—Mr. Hawkshaw, Mr. Glynn, Mr. W. H. Barlow, Mr. Locke, Mr. Fox, and Mr. Joseph Cubitt, are agreed in considering the bowstring form of girder, with a bow either of cast-iron or wrought-iron cells and the tension-rods of wrought-iron, as free from any objections urged against other modes of combining wrought and cast-iron. It is considered applicable, under almost all circumstances, as the roadway can be suspended from the bow.

Box or Tubular Girders.—Mr. Fairbairn considers these girders the best for large spans, and from some experiments he made, considers them capable of resisting not only dead weight but also impact. Mr. Stephenson states that they are cheaper and more elastic than other forms for spans of more than 40 feet, and he recommends that the top should be made of cast-iron to resist compression. Mr. Glynn and Mr. Locke mention that they have been used for steam-engines for some time, and consider the plan sound. Mr. Brunel looks upon the introduction of wrought-iron into the construction of girders as the most important step that has been taken for some time in engineering; and he considers that, with ordinary care, and with the improvements which have been introduced in the mode of riveting, the joints made by riveting may be as permanent, and in every respect equal to the other parts of the structure, and he does not consider oxidation or vibration can affect them. With respect to riveting, Mr. Brunel considers that two plates could be riveted together so as to ensure their not breaking in any part contiguous to the rivets or joints, because the rivets should not act as pins or bolts, but as clamps, which by pressing the plates together, produce an enormous friction. Mr. Clarke, however, who has made a good many experiments on the subject, does not appear to have obtained so close an union of the plate, as he states that they generally broke at the riveting. Mr. Hawkshaw has adopted wrought-iron girders for large spans, because he considers the use of wrought-iron more advisable than cast-iron for large spans: the box form is adopted to produce lateral stiffness. Mr. Fox and Mr. Rastrick consider that a large structure, like the Menai Bridge, must be subject to sudden compression and extension from the changes of temperature.

Suspension Bridges.—Mr. Stephenson does not consider suspension bridges applicable to railways except to very small extent; and he states that he has been informed that an engine and train passing over one at Stockton (which has since been replaced by a girder bridge), pushed the bridge like a wave in front of it. Mr. Brunel states that, under very peculiar circumstances, he once proposed a suspension bridge himself. Mr. Brunel considers that the lattice bridge is advantageous only under circumstances which would prevent materials of more than a certain length being procured. Mr. Stephenson objects that the compression cannot be carried through them, and that the base through which the strain has to be carried is not sufficiently broad. It is stated, however, that Sir J. M'Neill has remedied the want of power to resist compression by introducing a cast-iron top.

Best form for Bridges independently of Expense.—Mr. Rastrick, Mr. Hawkshaw, Mr. Fox, Mr. P. W. Barlow, Mr. Glynn, Mr. Locke, Mr. Brunel, and Mr. Cubitt, agree in considering that the best form for iron bridges of large span is that of a cast-iron arch. Mr. Grissell states that he considers a well-made straight girder equally to be depended upon, but admits that the arch is the strongest form; and Mr. Fairbairn says that for spans beyond 70 or 80 feet he would prefer wrought-iron tubular girders. Mr. Stephenson would use narrow wrought-iron girders.

Action on Skew Bridges.—It does not appear that the deflection of girders is sufficient to cause oscillation in engines passing over skew bridges, by causing one side to be deflected to the full amount before the other. But Mr. Stephenson mentions that when the road has been in bad order, one wheel being on the solid angle of the brickwork, while the other was on the soft ballast, has caused considerable oscillation.

Effect of Impact and Vibration.—It is not admitted that the vibration caused by a railway train on bridges would injure the bolts or rivets of compound girders, if well-made and strong in the first instance. Mr. Grissell gives them a large amount of surplus strength, as he thinks that when no greater strength of iron is put than is absolutely necessary, every jar must tend to loosen the joints, and he considers that vibration has much more effect on wrought iron than on cast iron. Mr. Fox states that he would not depend on a cast-iron girder of separate pieces bolted together without strengthening it with a wrought-iron tie-bar, but the use of wooden sleepers interposes a cushion which does away with the vibration. Mr. W. H. Barlow mentions that with light engines he found felt very useful in diminishing vibration, but that with the heavy weights now in use on the Midland line any interposing medium is crushed out. Mr. Stephenson attaches no great importance to vibration, and has laid iron girders on brick without interposing medium; and the fact of old cast-iron mill-work having run for so long a time without breaking is cited by Mr. Hawkshaw, as an instance of the apparently small effect of vibration. Mr. W. H. Barlow considers that the irregularities which exist on the road from uneven joints, &c. in the rails is a greater cause of danger than vibration, and he mentions that to experiment on the impact he caused the rails to be whitewashed for a mile before the passage of a fast train of 12 carriages, and that the small imperfections in the joints caused spaces adjoining them of 5 inches in length to be left untouched by any of the wheels in the train.

Change of Internal Structure in Iron.—Mr. Rastrick mentions that at the Pont-y-Pool Iron Works a bar of wrought iron suspended, and continually struck by a hammer at the bottom, dropped in two after a length of time, but he knows of no instance of a change of structure on railways. Mr. Hawkshaw, though he has observed crystallization in broken rails and axles, has not traced it directly to vibration: he thinks mill-gearing and shafts would furnish good examples, though when they break the various circumstances under which the fractures have taken place should be observed. Mr. Grissell has observed that the vibration to which crane chains are exposed changes the iron from very beautiful malleable iron to the crystalline appearance of cast iron. He does not consider that cast iron is subject to the alteration of structure. Mr. Fox considers that vibration does produce a change in the internal structure of wrought iron, and instances that if the thread of a screw be cut in a wrought-iron bar, and that the bar be broken across the tapped part, the fracture there will be found more crystalline than at the other part: he mentions the frequency with which shafts and mill-gearing break, and states that cold-hammering the axles to give them a high polish changes their internal structure; but instead of remedying the injury by annealing, he recommends that they should be finished at a high temperature. Mr. Grissell mentions that chains of cranes often break with a crystalline fracture, which he attributes to a change in the internal structure, but he does not consider the same effect is produced in cast iron. Mr. Fairbairn states, that repeatedly making a wrought-iron bar red-hot, and plunging it into cold water, renders it crystalline, and that the fibrous texture may be restored by annealing; he considers that percussion renders the fibres more liable to break off short, but that without it is sufficient to cause a considerable increase of temperature, it does not produce any real internal change. Mr. Glynn considers that the structure both of wrought and cast iron is altered by a succession of blows, the wrought to a crystalline structure, the cast to larger crystals; he has observed this appearance particularly in axles, mill-shafts, toothed wheels, crowbars, and crane chains, the latter even when specially made of strong fibrous iron require to be annealed after about three years; the axles of tenders to which breaks have been applied he mentions as particularly subject to this change. He attributes the alteration to galvanic action, induced by the alloys from which iron is never entirely free, and considers that the action is increased by blows. He also mentions that brass wire, of copper and zinc, originally tough and fibrous, continually breaks off short with a crystalline fracture radiating in the form of a star, showing a change in the structure such as would have taken place if the metal had been melted and had crystallized in cooling; this effect is more rapidly produced in an atmosphere containing sulphuric acid. Mr. W. H. Barlow mentions having caused a piece of fibrous iron to be hammered for a long time by a blacksmith, and that he found the iron changed from a fibrous to a crystalline structure; but as axles do not undergo the same sort of hammering, he does not know whether the same effect takes place in them. Mr. Stephenson considers the fact of an alteration of structure as highly improbable, and cites the connecting rod of an engine having vibrated 25,000,000 times, and yet being perfectly fibrous. In the cases of axles the iron may not have been fibrous in the first instance, for though when a piece of iron is rolled from 1 foot in length to 20 feet it necessarily becomes fibrous, it does not necessarily become so when rolled from 1 foot in length to 6 feet. He says that in all the cases of change of structure which he has heard of there has always been some important link wanting. Mr. Locke considers that concussion would alter the structure of iron, but would not offer an opinion as to whether the fracture of axles arose from that cause; he mentions that a great many axles broke when the crank axles were in use, but that since straight axles have been adopted fewer breakages have occured. Mr. Brunel doubts the change of internal structure, and thinks the various appearances of different fractures result as much from the mode in which the iron has been broken as in any change in structure, and that change of temperature will also produce a variation in the fracture; that iron in a cold state shows a more crystalline fracture than the same iron warmed a little, and that wrought iron does not actually become crystalline and fibrous, but breaks either fibrous or crystalline according to the combination of circumstances under which it is broken, but with the combination required he is not acquainted; he cites the stratification and planes of cleavage of rocks, which may be broken with different fractures according to the mode of applying the blow. Mr. Brunel exhibited various specimens broken, some with a fibrous fracture by means of a slow heavy blow, and some with a crystalline fracture by means of a sharp short blow. Mr. Charles May cites the beam of a steam engine as an instance of continued vibration not affecting iron, and mentions as an instance in favour of the change the fact that a gun used in his works to break pig iron across, at last dropped in two as if it had been cut.

Greatest Weights on Railways.—Mr. Hawkshaw states that locomotive engines are the greatest weights which can come on railways, and reckon 1¾ tons per foot linear as the greatest weight for a single line of way. Mr. Fox, Mr. Fairbairn, and Mr. Brunel mention 1½ tons. Mr. W. H. Barlow states that on the Midland there are engines on four wheels weighing 32 tons exclusive of the tender, but that that weight is too great for the permanent way, and that the rails are crushed and flattened by it. Mr. Stephenson and Mr. Locke state, 1 ton per foot linear is the greatest weight which comes on a single line of rail.

Analysis of the Evidence given by the Witnesses examined.

John Urpeth Rastrick, Esq., Civil Engineer.—Has experimented on Staffordshire and Shropshire iron. Prefers forge iron for large castings. With pure mine hot-blast iron is equal in strength to cold blast, but the hot blast enables cinder to be used, which deteriorates the quality. The temperature of the blast alters the quantity but not the quality of the metal produced, about 500° or 600° is preferred. The only guarantee against bad iron is to contract for a particular quality. There is no mode of detecting the difference between two kinds of iron. A mixture of the Penistone ore from Shropshire with the Staffordshire ironstones improved the quality of iron. For strong castings a mixture of pig iron is preferable to mixing the ores; a good mixture is formed from Low Moor iron, Old Park iron, and Colebrooke Dale iron. Cast the bridge at Chepstow. Allows a ton as the breaking weight of a bar 1 inch square and 1 foot between the bearings. Proves a beam to 1-3rd of the breaking weight, but never trusts it to carry more than 1-6th. Iron girders may be cast of almost any length provided they have strength in proportion; made beams for the British Museum 41 feet long in 1824 or 1825, the had open work in the web, and were 3 feet or 3 ft. 6 in. deep; they were proved by laying on 15 or 20 tons of actual weight, and struck with a heavy hammer of 14 or 20 pounds weight. In simple girders, if the height is too confined, the strength required must be given by thickness. A girder will bear the same weight on the bottom flange as on the top. The torsion caused by placing the weight on the bottom flange is very trifling, and cannot take place without a greater amount of deflection in the bearer than should be allowed. Puts on brackets to unite the flange to the girder. The strength of the joists supporting the roadway should be sufficient to prevent them pushing out the flanges. A flange never breaks off. As long as a weight on a girder is not sufficient to injure the elasticity no matter how long it remains. A beam taken out of a mould while hot will break by its own weight. Cast iron is more fragile in winter than in summer. In the Chepstow Bridge of 112 feet span, versed sine 8 feet, the difference of temperature between summer and winter altered the position of the crown of the arch by 2 inches. Bridges requiring a flat soffit are best supported by a bow above the roadway. No combination of wrought or cast iron is equal to a solid casting, the two metals hamper each other. An arch is the best form for a bridge of cast iron. Vibration and impact will not injure the joints and rivets of compound girders if they are strong enough. Railway girders should be so strong that the deflection should be immaterial. At the Pont-y-pool Iron Works a bar of wrought iron 1 inch square was hung up by one end, and struck at the bottom by a small hammer continually for 12 months until the bar dropped in two. The vibration upon a railway bridge is too small to affect it. Doubts whether the fractures of railway axles can be attributed to vibration. If in a railway bridge no permanent deflection has taken place after it has been in use for 12 or 18 months, considers it has not been affected by the running of the train. Has not observed that fish-bellied rails break from becoming crystallized. In proving a girder allows a deflection of $\frac{1}{500}$ of the length. Considers a rapidly passing weight will cause less deflection than a stationary weight. Prefers cast iron in all cases to wrought iron, In a span of 100 to 200 feet an arch is best; if the height does not admit of it under the roadway it should be placed above. The difficulty of transport is the only limit to the length of castings.

John Hawkshaw, Esq., Civil Engineer.—Low Moor iron is the best for girder bridges, good grey Staffordshire the next best. 1-3rd of No. 1 and 2-3rds of No 2 of the best Staffordshire or South Wales iron is a good mixture for large castings. Hot-blast iron is not so strong as cold-blast iron. The only guarantee against the use of hot-blast iron is the character of the founder. The strength of a girder should be seven times the load, and would test it to at least double the load. The spans for simple cast-iron girders might be increased beyond those in use. Would not hesitate to make a simple cast-iron girder of 100 feet span. In designing a simple cast-iron girder obtains the form for the requisite strength by Mr. Hodgkinson's formula, and trebles the area of the top flange to get lateral stability, thus making the top flange half the area of the bottom. In testing beams it is desirable to give vibration by blows while the pressure is on, or if actual weight is applied, to throw the weights into the scale. A girder cannot bear so much weight on one of the bottom flanges as if applied at top. The weight so applied produces a torsion. By increasing the top flange and adding brackets, the torsion is diminished. It would be nearer a practical result to test a beam in the way in which the weight will be applied. The objection to contrivances for throwing the weight in the centre plane of the girder is that by departing from the simple form the liability to unsoundness from the casting is increased. It is possible that weak girders loaded with a permanent weight might increase in deflection after a length of time. The deflection of a girder should be almost imperceptible. The Knottingly Canal Bridge of 89 feet span deflected half an inch with an engine of 22 tons going at 50 miles per hour; the bridge is too weak. Prefers not using compound girders, it is however possible to make them strong and safe. Prefers plain girders with the top flange increased to prevent lateral twisting. It would be useful to ascertain the strength of beams under loads applied as in practice. For spans of 100 or 200 feet which must be crossed with a level soffit a truss like that for a roof is preferable, or a bowstring bridge. Joints and rivets will not suffer from vibration if made originally strong. Where there is impact or vibration there should be large surplus strength, a breaking strength of seven times the load. Has seen numberless cases of broken axles and broken rails, when frequently crystallization existed, but cannot say whether it is attributable to a succession of blows. Experiments on the subject are desirable. Mill-gearing affords examples already made; the cast iron is there subjected to blows and vibration, and the machinery goes on running for years. The use of cast iron in mill-gearing gives confidence in its application to other purposes; by inquiring into the wear and tear of mill-gearing, the length of time that iron will bear shocks might be ascertained. The irregularity in the surface of the rails would cause a weight moving with velocity to deflect a beam more than a similar stationary weight. No practical velocity would be such as not to give time for deflection. Ice does not afford a parallel case; ice has a better surface, and time must be allowed for the displacement of the water. Is erecting two bridges with wrought-iron tubular girders. Wrought iron gives more warning than cast iron. The load on railway bridges may be taken at 1¾ tons per linear foot. The heaviest load is a locomotive engine: there is a rule on all railways prohibiting trucks being loaded beyond a certain point. Locomotives weigh about 22 tons, and the tenders 10 or 12 tons. The weight on a bridge covered with locomotive engines, including the roadway would be 2 tons per linear foot. It is desirable to ascertain the real facts with regard to the trustworthiness of cast iron. The conditions under which cast iron is placed in railway structures is similar to that in mill-gearing, and the quantity of cast iron shafting and length of time it has been in use might be ascertained. Is making a wrought iron bridge of 100 feet span; it appears easier to construct one of that span of malleable than of cast iron. The cost determined the adoption of wrought iron; objects to the combination of wrought and cast iron except in bowstring bridges. The wrought iron girders are made double, to obtain lateral stiffness. Without reference to expense, an arch is the best form for cast iron. The level soffit is adopted from necessity. For the strength of wrought iron girders, Mr. Hodgkinson's formula for cast iron was used, adopting 70 as a coefficient instead of 28, and taking care to make the upper flange strong enough; has not had enough to do with that form of girder to be certain of the precise proportions.

Charles Fox, Esq., Civil Engineer.—The mixtures to be preferred for particular works depend upon the locality, as the cost must be considered; would use in the Midland Counties iron from Staffordshire and Shropshire, on the sea coast Welch and Scotch. Two-thirds Blaenavon (cold blast Welch), and one-third of Scotch in equal proportions from the Blackband and from the Red Hematite, is a very good mixture. Is convinced that metal made by the hot blast would be as good as from cold blast if the mine were properly treated; but the custom in Scotland has been to care for quantity not for quality. The only guarantee against inferior metal is to contract that girders shall not break with less than a specified weight, and to cast one more than is required, and select any one for trial, and if it fails reject the whole. In girders not subjected to vibration, considers that the greatest load should not exceed one-third of the breaking weight; in girders for railway bridges, one-fourth. Proves girders to double the greatest load. For girders of new forms applies the proof by dead weight; but in known forms, uses the hydraulic press as being more convenient, observing the amount of deflection. Considers the objection to the hydraulic press obviated by the use of cylindrical instead of conical valves. The load on one of the bottom flanges is not objectionable provided the girder does not cant. Tests girders sometimes by a weight applied to one of the bottom flanges. Considers a span of about 50 feet as the limit for simple cast iron girders. For girders to support a quiescent load would make the section of the top flange one-sixth that of the bottom. In a railway bridge, where the top table would not be supported laterally, would make the area of the top table one-fourth that of the bottom. In a railway bridge, where the top table is supported laterally, makes the area of the top flange one-fifth that of the bottom. The top flange of a girder being subject to compression may be compared to a column; and if bent, its liability to break will be increased. If circumstances required, would make a girder of more than 60 feet long in one piece; roving bridges over the New Birmingham Canal are 80 feet long, cast in one piece. In well constructed bridges the deflection of the platform should not cause any injury. Considers the smallest weight applied impairs the elasticity of a beam, and that a girder exposed to change of temperature and vibration will swag, and that this effect will go on increasing; but he considers that the only diminution of strength from this is due to the diminution of the sectional area of the bottom table; but that in cases where a beam is not subject to change of temperature, it would retain its original position. Instances some girders 6 feet long for supporting hoods to smiths' forges, which are warmed by day and allowed to cool at night; they swag nearly 3 inches in the centre. Considers that in the alteration in the arrangement of the particles of iron caused by a change of temperature the weight takes advantage of the change. Does not consider that removing and replacing a weight on a beam continually would have quite the same effect; mentions that anchors when tested take a week to regain their original position; considers alteration of temperature more likely to produce swagging than vibration. Thinks that railway girders will gradually swag and must be exchanged, and that few which have been ten years in use have not swagged, but that their strength is only impaired to the extent mentioned above; the greater the inertia of the bridge the longer would the action be delayed. Considers the mode of supporting the roadway on one side of the girder to be wrong. The deflection of a girder should not be considered with reference to the span. For large spans, prefers cast iron on the principle of compression. Would make straight girders for large spans of several castings bolted together with wrought iron tension rods fixed horizontally along the bottom flange, and put considerable initial strain upon the wrought iron bars, that the cast iron may come into operation when the wrought iron is under a considerable degree of tension, so that the ultimate effect from the two may be obtained. The expansion produced by changes of temperature being only a differential quantity, would be small in a length of 100 feet; and the wrought iron being more elastic than cast iron, should bear it. The bow string girder, with a bow of cast and a string of wrought iron, would be cheap and safe. A bridge for crossing the Arno is being made of straight girders on the above mentioned principle; the wrought iron bars are under a tensile power of 6 tons per square inch. In process of time the wrought iron would stretch; wrought iron would stretch $\frac{1}{18}$th inch in 10 feet, with a weight of 10 tons. Would not let rails rest on the top of a wrought iron riveted girder without a piece of wood between. Girders made of separate castings should, in addition to bolts, have a wrought iron tie bar. Soft timber between the rails and girders will prevent danger from vibration. Considers alteration of temperature as likely to subject wrought iron girders to a great deal of undue compression and extension. Thinks experiments on impact and vibration desirable. Believes that wrought Iron is rendered crystalline by a succession of slight blows at a low temperature, and has observed that the older axles are, the more crystalline they are; also remarks, that if the thread of a screw be cut on a bar of fibrous iron, the tapped part will break with a more crystalline fracture than the other. Shafts in mill work break and exhibit a crystalline structure. Thinks cold hammering injurious to axles from tending to make them crystalline, and also from producing a strain like that produced by straightening castings by hammering. Would prefer their being finished at a high temperature to being annealed. Cold hammered axles may be detected by their appearance. Thinks experiments on long continued deflection are very desirable. In estimating the strength of a girder, adopts as the greatest weight 1¼ tons per foot per single line of way; that is ¼-ton per foot for weight of platform and 1 ton per foot for weight of train; for two girders of 40 feet span, would take the weight at 60 tons distributed, equal to 30 tons in the centre. Would calculate the breaking weight of each girder at 60 tons in the centre, and prove them to 30 tons. Considers that with a carefully laid road the deflection due to rapidly moving weights is less than that due to such weights at rest, from the shorter time allowed to overcome the *vis inertia* of the bridge. There has been a great want of fixed principles in the construction of railway bridges: no general principle has been laid down; whilst one engineer is satisfied with one amount of proof, another adopts six times as much. In making contracts for railway chairs, stipulates that the mixture he uses when cast into a bar of a certain form shall break with a specified weight. Is inclined to think the castings from the air furnace better than those from the cupola, but the difference is very minute.

Henry Grissell, Esq., Iron-founder and Machinist.—Amongst other large works, is at present constructing a built girder bridge for a span of 121 feet; it is 12 feet high, and weighs 100 tons; it has been proved to 108 tons distributed over it. Has not studied the chemical constitution of iron. Prefers a mixture of iron for castings. The mixture depends on the state of the markets; and from old iron being so plentiful in London, pig-iron is not considered so much as in the country. Mixes Scotch iron, old iron, cold-blast Welch iron, the proportions being dependent on the appearance of the fractures; for cylinders a larger proportion of cold-blast iron is used than for girders. Considers London castings 15 per cent stronger than country ones, from the use of old iron. Hot-blast iron when mixed is as good as cold-blast, but alone it is not to be depended on. The proportions for mixtures are so dependent on the qualities of iron, that he is guided by the appearance of the fractures in determining them. Considers he could mix iron so as to make a casting bear any weight in reason. Could not tell hot-blast iron from cold-blast iron from the fracture. The proportion of stress to strength varies with the section of the girder and the strains to which it is subjected; generally considers the load should be one-third the breaking weight for railway bridges. Handed in the rule he adopts in calculating the strength of girders. Has made simple and compound girders. Would make a girder in one casting 50 or 60 feet. Considers a level top flange a waste of metal. In designing a girder, judges by the eye of the probable strains it would be subject to, and then calculates the strength, and alters the form so as to obtain the greatest strength with the least quantity of metal. Adopts the double T section, the bottom flange being largest. Girders may be proved by a lever or an hydraulic press; the latter is what he usually adopts, and it is as certain as the lever when correctly made. Does not think a girder will bear the same weight if applied only on one flange as if applied to both equally. Proves girders to find out whether the casting is sound, and so applies the proof to the top. Has never noticed that length of time or change of temperature makes beams swag. For compound girders prefers the built girder. Considers half an inch deflection may be allowed in every 20 feet of length; can regulate the deflection by the mixture of iron he uses; would not consider a beam injured by a deflection of ¾ inch in 20 feet, if it returned to its original position. For large spans when not tied by expense or height, would generally prefer a built girder. But thinks that an arch is a stronger form than a straight girder, but more expensive, Would guarantee a straight girder with top and bottom flange to bear any amount of pressure. Would not hesitate to use one for a span of 200 feet; thinks it would bear any weight that could come on. Does not think impact and vibration would affect large bolts and rivets, but that where no more than just the necessary strength is put in, every jar would tend to loosen them. Thinks vibration dangerous to wrought-iron; vibration takes much more effect on wrought than on cast-iron. Has observed in crane chains an alteration in the structure of the iron, after a few years' use; instead of its breaking with a black tensile appearance, it breaks short and white like cast-iron; it is changed from beautiful malleable iron to the appearance of very good cast-iron. Cold hammering will also produce this effect on cast-iron, but it can be restored very nearly to its original texture by annealing. Feels convinced wrought-iron girders will become altered to a crystalline texture by vibration. Knows no case of cast-iron becoming altered, or breaking from vibration alone. Has not given his attention to axles. Has made numerous experiments on iron of all sorts and mixtures. Considers that if the form of a girder be given him, he could mix the iron for making it to such a degree of nicety, [that he could guarantee any amount of deflection, and carry any load required in moderation. Attaches the greatest value to old iron, but not to differences in pig-iron; considers all Scotch iron to be much of the same quality, except one or two sorts, which are very superior. The metal for mixtures must be selected with great judgment. Does not consider it necessary to try the relative strengths of the different sorts of metal before mixing, but judges of the proportions by the fracture. A good mixture would be one-third hot-blast iron, one-third old iron, one-third Blaenavon Welch iron, but he does not confine himself to one particular mixture.

Peter William Barlow, Esq., Civil Engineer.—Has been employed chiefly latterly on the South-Eastern Railway. Has not observed much difference in the strength of castings. Has always made the breaking weight of girders six times the greatest load for railway bridges. For other works four times would be sufficient. Proves girders to one-third of the breaking weight, or double the greatest load. Prefers proving them with actual weight, and giving some vibration to the beam by putting on the weight. Girders will not bear the same weight when resting on the bottom flange as if applied at top. Has adopted another form of girder, the object being to make the bridge one complete plate. Considers 40 feet as the limit for such a bridge. Has made one over a railway at Tunbridge wells. Finds that the deflections are less than he calculated, from the assistance one part affords to another. Has not observed any injury from the bending of the joists which carry the roadway between two girders. Has not noticed any increase of deflection from a permanent load or from changes of temperature. Allows $\frac{1}{800}$th of the span for the deflection of a girder. The deflection of the Godstone Bridge is $\frac{1}{800}$th of the span, or $\frac{3}{5}$ths of an inch. Proposes 40 feet as the limit for simple cast-iron girders. Used a level and levelling staff for obtaining the deflections of the Godstone Bridge. Considers the girders rest so firmly on their beds, that the deflection observed is not due to any yielding in that respect. Depends on Mr. Hodgkinson's rules for the form of construction for girders. Has made no experiments on the amount of torsion caused by supporting the roadway on the bottom flange of a girder. Considers a girder of separate castings bolted together is a good mode of construction beyond spans of 40 feet. Would not use that method for bridges of 100 feet span. Would limit girders cast in one piece to 40 feet span. Does not consider suspension rods a good mode of combining wrought and cast-iron. Would lay a wrought-iron rod along the bottom flange. Assistance given to the extended part of a beam is more effective than when given to the compressed part. To avoid a large mass of cast-iron, would lay a wrought-iron rod along the bottom flange. Does not consider that the different rates of expansion would prevent the wrought-iron coming into play. When the bridge gets much load it must come into play. Prefers an arch of cast-iron where expense or height is not a matter of consideration. Is making one over the Surrey Canal of three pieces bolted together. Does not consider the vibration on a railway bridge sufficient to disturb the screws. Does not consider that there is much difference of effect between engines going fast or going slowly. Does not think vibration so important as is imagined. Fancied he observed an increase of deflection from engines going fast; there was a great deal of horizontal jar. Which he attributes to blows given by the engine on the rails. Some may be due to the torsion created by the weight being on one of the bottom flanges. Has not observed any change produced in the internal structure of iron from repeated blows at a low temperature. Thinks the subject an important one, and that experiments could be made best by breaking beams which had been long in use. Or testing girders whose previous test had been recorded. Engines and tenders are being made, weighing together 32 tons. Engines for inclines weigh as much as 30 tons without a tender. In estimating the greatest load for a railway bridge, considers it covered with a train, or a train composed of engines. Considers the Commissioners might make some useful experiments on the Godstone Bridge. Has paid attention to wrought-iron girders. It is desirable in a girder to concentrate the power of resistance as near the top as possible, and the power of extension as near the bottom as possible, which can be accomplished in a cast-iron girder; but in wrought-iron tube girders the bottom web, which does most work, is a very small proportion of the whole section. Prefers wrought-iron, or wrought-iron combined with cast-iron, to resist compression, to cast-iron alone. Considers solid-sided wrought-iron girders an imperfect mode of construction. Thinks the top of tube girders should be of cast-iron. For a large span, considers wrought-iron safest. On account of the uncertainty of cast-iron would make a cast-iron girder 50 per cent. stronger than a wrought iron one. The relative expense would be about half.

William Fairbairn, Esq., Civil Engineer.—In early life was a mechanical engineer. Has been employed in engineering works of various descriptions. Thinks Welch cold-blast iron, Blaina, for instance, best for girder bridges. Considers most British irons improved by mixture. A good mixture is two-thirds strong Welch, No. 3, the remainder Scotch or Staffordshire, No. 2, with a little old iron. The same mixture is used in girders for railway bridges and girders to support dead pressure only. Thinks Mr. Morries Stirling's patent for mixing wrought iron with cast iron gives indications of very superior strength, and states the results of experiments upon it; also cites experiments by Mr. Lillie, of Manchester, on the mixture of wrought and cast iron, which proved that the mixture was one-third stronger than common cast iron, and one-eighth stronger than wrought iron to resist transverse pressure. Considers the following mixture of cast iron the best, viz.:—

Lowmoor, No. 3	30 per cent.
Blaina, No. 2	25 per cent.
Shropshire or Derbyshire, No. 3 . . .	25 per cent.
Good old scrap	20 per cent.
	100

This mixture can rarely be obtained on account of the price of Lowmoor, and founders cannot be depended upon for the exact proportions. Practically he doubts any mixture unless the parties interested were present to witness the selection of the iron, and to see it put in the furnace. Scotch and Staffordshire iron are good for light castings. Good castings depend on the care of the furnace man, the temperature of the furnace, and the heat at which the metal is run into the mould. Recommends the anthracite iron where rigidity and strength is required. The strongest iron should be put in railway bridges. Considers that the hot blast does not improve the quality of Welch and English irons; but that its application in the Scotch furnaces to the reduction of the black band is an improvement. Scotch hot blast mixes well with Welch irons. The effects of the hot blast vary with the quality of the fuel and ore, and much depends on the quantity of sulphur present in the coal and coke. The Lowmoor ores were injured by the application of the hot blast. Fuel is an important element in the manufacture of iron, the nearer it approaches pure carbon the better. In the Scotch black band and similar ores the hot blast will bring more iron out of the same mine than the cold blast. The hot blast enables the manufacturer to work up not only poorer ores but cinder heaps, into apparently fine granulated iron. The use of the hot blast at first led to the introduction into the market of a very inferior description of iron. Considers the Scotch iron weaker and more fluid than most English irons; it is equal to Staffordshire, but weaker than Welch and Yorkshire. Scotch iron is an exceedingly fluid and fine-working iron, and well suited to machinery; it runs well into the mould, and brings out the castings with the edges sharp. Does not think the most experienced metallurgist could tell the difference between hot blast and cold blast iron from the appearance. Considers that hot blast presents greater uniformity than cold blast in its granulated appearance, and indicates a more perfect process of crystallisation, probably arising from the greater heat of the furnace. In cast iron girders, would make the breaking weight four times the greatest load. In structures exposed to shocks or vibratory motion would adopt five times or six times. It is safer to adopt a light load, so as to make allowance for casual strains which cannot be computed. Never proves a girder to more than half the breaking weight, generally one-third; disapproves of testing a girder much beyond the permanent load, the object being to ascertain its soundness and elasticity; a further test tends to permanent injury. In testing girders, carefully inspects the outward appearance, and then hangs weight from the centre, and observes the deflection and permanent set. Does not consider that a permanent set given to beams in the early stages of loading injures the strength. Thinks that within certain limits the form of a beam may be distorted without its strength being injured. Considers that to support the load on one side of the bottom flange is wrong in principle, and to a certain extent injurious in practice; but the method has many conveniences: to meet the requirements of structures, self-evident principles must in practice be sometimes abandoned. When the load is supported on the bottom flange, the bearing should be brought as close as possible to the central web, by casting a fillet or shelf to carry the cross-beams: bolt holes should be made as near the neutral axis as possible, or when required for bolting wooden bearers to the bottom flange, projections on the bottom flange should be cast to receive them; bolting the roadway to the girders resists, in a great measure, any lateral strain on the girders; but the lateral strain is best resisted by broad top and bottom flanges. Considers bolt holes and other perforations in cast iron girders very objectionable, and they should in no case be made, even through the neutral axis, without thickening the adjacent part to compensate for the part taken out. These objections arise from considering the complexity of such a girder and the additional material required to make it equally strong as if plain. Is an advocate for simplicity of construction in everything, and would only allow distortion of form when inevitable. Would prefer supporting the cross bearers on the top flange or suspending them from the bottom flange by hook bolts. Supporting the road on one side of the bottom flange is wrong in principle, but convenient. If the top flange be broad and rigid, that mode of construction is less objectionable. It would be advantageous to seek for a new form of beam; a narrow top flange, though well proportioned for vertical pressure, is weak to resist lateral strain. The practice of supporting the roadway on the bottom flange is simple, cheap, and convenient, and will not easily be abandoned. Recommends a new form of girder to be sought for, to give the girder sufficient stiffness. Has himself always increased the top flange to resist the lateral strain. In a large span with girders having small top flanges, the lateral deflection, if not resisted by a firm connection of the cross beams to the girders, might cause an outward pressure dangerous to the structure. As girders are generally tested to ascertain their soundness, it is usual to apply the test to the top flange, but it would be of great value to test them as they are to be used. The test is usually applied to ascertain the soundness of the casting, the strength being computed at three or four times the load. The joists which support the roadway when carried on the bottom flange, tend to cause by their deflection a lateral pressure on the girder. This effect takes place to some extent in wooden and Sandwich beams; from experiments it appears that this latter description of cross beam is weak, and its elasticity so imperfect as to render it inadmissible for supporting great weights. The Sandwich beam is objectionable and expensive. Is of opinion that a beam loaded with a given weight, even approaching its ultimate powers of resistance, would support the load *ad infinitum* if not disturbed or exposed to changes of temperature; although time is an element in the change which takes place in every material, any increase of deflection in a loaded girder may be traced to atmospheric action, vibration, change of load, and temperature: remove these disturbing causes and the deflection will remain fixed. Cast iron of average quality loses strength when heated beyond a mean temperature of 220°, becoming more ductile and less rigid to resist an uniform strain, and becomes insecure at the freezing point or under 32° of Fahrenheit. In girders of 40 feet span $\frac{4}{5}$-inch is the maximum allowable deflection, that is, ·02 inches per linear foot; ·005 inches is preferable. Adopts Mr. Hodgkinson's form of girder modified in the top flange to ensure uniformity in the casting. Considers 40 feet to be the greatest allowable length between the supports for simple cast iron girders. Knows an instance of a girder 70 feet long, cast in one piece in Holland. Never heard of a girder breaking by its own weight; a properly proportioned girder could not do so. For spans beyond the limit of simple cast iron girders which must be passed with a level soffit to the extent of 100 or 200 feet, recommends the wrought iron tubular or box girder. Being a strong advocate for simplicity in mechanical structures, he would not recommend compound girders where they can be dispensed with. Approves of wrought iron tension rods to girders only in cases of necessity, and where the top flange is enlarged, but prefers girders all of one material, even if formed in parts. Would rather give strength to a cast iron girder than assist it by a wrought iron truss; the two materials are so widely different in character that it is safer to keep them separate. By screwing up the tension rods a strain is thrown either on the girder or on the tension rods themselves; an ignorant person might do injury without being aware of it. When not limited by expense or levels, would prefer for narrow spans a simple girder; for moderately wide spans, the arch; for spans exceeding 70 or 80 feet, the wrought iron girder. Thinks that no vibration to which railway bridges are subject can injure the joints or rivets, unless the work is shamefully executed; nor would impact have any effect on the joints of a well-made cast iron girder. Does not think any effect is produced by the load in skew bridges being alternately nearer one side than the other. It is the opinion of some practical men and philosophers that iron when hammered at a low temperature undergoes a complete change in its internal structure, and that this effect is due to percussion, heat, and magnetism, and time, which is an element in every process of crystallisation. The application and abstraction of heat operates more powerfully than probably any other agency; too much influence is probably attributed to the other mentioned causes; a bar of the best wrought iron, heated red hot and plunged into cold water, is changed from a fibrous to a crystalline body; heating and cooling will produce this effect in a degree proportioned to the intensity of the heat applied; by annealing the iron its fibrous texture is restored, and sometimes made more tough than before. Thinks magnetism may have some effect; but often where causes are inexplicable we fly to electricity for the solution; heating iron to a high temperature deprives it of its magnetic powers which are restored by cooling. Doubts that vibration changes the fibrous structure to a crystalline one, but thinks that each blow produces injury. Axles of a locomotive engine are subjected to repeated shocks from irregularities in the rails and lateral action in passing curves, from a body weighing 18 or 20 tons, moving at 40 miles per hour. Each percussion tends to bend the axles, and from the injury being continued many thousand times, it is evident that time alone will determine the moment of fracture. If the axles were so rigid as to resist the effect of percussion, no injury could ever take place or crystallisation appear. A bar beat with a small hammer is not altered at all, but the blows of a large hammer produce a change of form which renders it brittle, not probably crystallising it. Is of opinion that a fibrous body cannot be changed to a crystalline one by any mechanical process, except when percussion is carried on to the extent of producing a considerable increase of temperature. Fibres may be shortened by continual bending, and the parts be thus made brittle, but fibres cannot be changed into crystals. These changes apply to all materials subjected to repeated alterations of form. Has not traced the breaking of mill work to the change of internal structure. The shafts usually break eventually from getting out of line. It would be interesting and useful to experiment on the above points. The greatest weights on railways may be reckoned at 1½ tons per foot linear for a single line, or two tons per foot for a double line of rails. Considers that recommendations made by the Commission as to particular forms for bridges would probably not be followed, but that experiments would be very beneficial.

Joseph Glynn, Esq., Civil Engineer.—Was engineer-in-chief to the Butterley Company. Cast iron is always combined with earths, as lime and silica, as well as with carbon; the more pure the iron is the stronger it is. Never saw pure iron. Iron cast from the air furnace of a mottled or of a clear grey fracture, bears the greatest weight. Iron cast from the air furnace is stronger than from the cupola. Doubts the utility of mixing wrought with cast iron for increasing the strength of iron; doubts the complete union of the two. The quality of iron depends, to a certain extent, on the ore, fuel, and flux used; and an experienced person can generally tell what the produce will be. From a reverberatory furnace the required mixture can be invariably produced. The length of time iron remains in the furnace affects the quality. In the air-furnace it is weakened by remaining too long. The best mixture for girders is about one-third of strong crystalline Welch iron with two-thirds of the softer irons of Derbyshire, Yorkshire, or Shropshire. The hot blast of itself produces no effect on iron. It may be used to smelt stubborn untractable materials that would not afford strong iron, and could not be otherwise smelted. In the west of Scotland inferior iron has been produced by means of the hot blast. There is no certain mode of detecting the difference between hot and cold blast iron, but iron of a dark grey colour and very fine in the crystal, is generally hot blast. The difference is more marked as iron is harder. Loam castings are stronger than open sand. Casts machinery required to be very strong from the air-furnace in dry sand. A shaft cast in an upright position is stronger than one cast horizontally on account of the impurities floating to the top, and the density being increased. Adopts the H form for the section of girders, the bottom flange being largest. Would not make a simple cast iron girder more than 50 feet long. Where spans have exceeded that, has always used the arched form. Built an arched bridge of 70 feet span over the Aire, at Haddesley; and one of 100 feet span over the Trent on the Midland Counties Railway. Would invariably employ an arch when possible. Would not employ wrought iron as an auxiliary to cast iron in point of strength. Would only employ it for bolts; on a large scale the workmanship cannot be so accurate that each will bear its share of the stress. For spans beyond 50 feet, would give the girder as much depth as possible, and join the pieces by bolts and dowels. Would not have a wrought iron truss. When the workmanship is good, does not consider the vibration and impact can affect the bolts and rivets. Believes that the internal structure of iron becomes altered by being submitted to a succession of slight blows at a low temperature. Has seen many axles broken which presented a coarse crystalline fracture. The continual succession of blows induces fracture, and changes the internal structure of fibrous iron to crystalline, the crystals increasing in size as the effect goes on. Crane chains made of fibrous iron break in a few years with a crystalline fracture. Considers the same effect takes place in cast iron. Shafts in mill-work break. And there appears to be a limit as to time in the durability of wheels. The fractures in these cases exhibit an increased size of crystals. Considers that a stationary weight would deflect a beam more than a moving one. Never made large girders of wrought iron plates; the method is adopted for paddle beams of steam-vessels, vibration has not affected those made for steam vessels, nor did the rivets become loose. Considers that the strength of a wrought iron girder is diminished by rivets.

William Henry Barlow, Esq., Civil Engineer.—Is resident engineer to the Midland Railway. Has found so much difficulty in obtaining the quality of iron specified that he now simply specifies the dimensions of the girders and the test to which the iron is to be submitted, leaving the mixture to the founder. Objects to the inferior qualities of cinder iron and hot blast iron generally; though, at times, hot blast iron exhibits good results. Some specimens of hot blast are as strong as cold blast. Hot blast iron seems more liable to abuse in manufacture than cold blast. Is not aware of any mode of telling hot blast iron from cold blast. Specifies that girders should bear a given weight with a given deflection. Would make a girder so that the breaking weight should be four time the greatest load. Considers that safe for weights moving at high velocities. Proves a girder to half the breaking weight. It gives the girder a permanent set, but does not consider that it injures its strength. The proof is proportioned to what the girder has to bear. Tests them by dead pressure by the hydraulic press. Has not tried impact, during the test but thinks it might be desirable when the breaking weight of the girder is nearly approached; but, practically, would give a large amount of surplus strength. Never allows the load to exceed one-fourth of the breaking weight; it is often one-fifth. The pressure being applied in the central plane of the girder. In actual structures the pressure is usually applied to one side of the bottom flange, but does not consider that when the surplus strength is so great and the iron good that it is of importance to apply the test in the same way. A torsion is introduced; it is not, however, so perceptible in short girders. The effect of a great permanent load on girders is not in operation in railways; but girders do not appear to be deteriorated by the frequent passage of a load. The one-fortieth of an inch to a foot is assumed as the amount of deflection that may be allowed in girders, but it is empirical. The short time which a load rests on a railway girder apparently renders the weight of less effect than in warehouse girders which bear a large load for years. Observed once on a timber viaduct that a goods train produced a certain amount of deflection; an express train coming afterwards, though with a lighter engine, seemed to produce a wave through the bridge, and evidently produced a worse effect than the goods train. The point of maximum effect would not be when the load was in the centre of the bridge. And this is probably a reason for allowing girders to deflect less in railway bridges than when exposed to dead pressure only. Has generally adopted Mr. Hodgkinson's form of girder. In spans of 50 feet, whenever the headway allows, prefers and has adopted arched girders, which are supported by abutments, and also act as girders. A skew bridge on that principle is a series of square bridges. The arched girder for the bridge over the canal at Weelock is in two pieces, bolted together in the middle; the rise is one-tenth. There are cases where on account of the headway rectangular openings are required, but they are rare; girders have been used to a greater extent than necessity required, from being in fashion. The length for cast iron girders will be limited by the power of casting them; has not used any longer than 42 feet. The bowstring bridge is the best mode of construction where the spans are too large for simple girders, a cast iron arch with a wrought iron string. In a very large structure the rise of the arch might allow of a pair being tied together at the top. If in combinations of wrought and cast iron, the two metals are bolted side by side, the different rates of expansion might produce a bad result. Has not found that the impact and vibration to which railway bridges are subject has produced any bad effect on the bolts and rivets of bowstring girders. The girders in skew bridges might, if the deflection were excessive, suffer from the load coming on the centre of one girder before it comes on that of the other. Except at high velocities the maximum effect will take place when the load is at the centre. To try the effect of impact of trains, whitewashed the rails for a mile on an incline of 1 in 316, and watched the effect of a fast train of 12 carriages going down it over them; in cases of imperfections at the joints, there were spaces 5 inches in length untouched by any wheels in the train. The rails weighed 78lb. and were on wooden sleepers. Used to use felt as an interposing medium to diminish vibration, which answered for light engines; the present ones are so heavy that any substance is soon crushed out.

Some engines weigh nearly 30 tons; a new one on four wheels weighs 32 tons. Has observed that the internal structure of small pieces of wrought iron becomes altered by blows. Caused a piece of the best and most fibrous wrought iron from the Lowmoor works to be hammered by blacksmiths for 10 minutes, and quite a change in the texture was produced; by continuing the hammering for half-an-hour, it was altered from a fibrous to a granular texture. Axles are not exposed to the same sort of blows as hammering gives; but axles have broken with a crystalline fracture. The very heavy engines lately introduced begin to crush the rails; eight tons on each wheel seems beyond what the rails as now constructed can carry. The wheels of the large engine above mentioned are 16 feet apart. It has travelled with two carriages at 78 miles per hour.

Robert Stephenson, Esq., M.P., Civil Engineer.—Mentions that it is well known that the fluidity of Berlin iron is due to the presence of arsenic, and that the Welch and Yorkshire irons are contrasted by the one being hot-short and the other cold-short, which is due to the presence of phosphorus on the one hand and manganese on the other. Used two or three cwt. of the new iron from India; but the workmen did not understand it; it retains its malleable properties to a high temperature, and then loses them very suddenly and becomes fluid. Mr. Morries Stirling's method of introducing wrought iron into cast iron, is a commercial question, unless it gives more flexibility or toughness to the cast iron and makes it approach the quality of wrought iron; for if the additional quantity of common iron required to make up for the difference of strength can be introduced at less expense than his mixture can be procured, he would be beat out of the market. Weight is, however, an important element in steamboats. Prefers a mixture of irons wherever it can be obtained, without having any specific opinion as to which mixture is best. Made several experiments on mixtures at Newcastle; does not think the difference between any irons so great as to make it worth while incurring additional expense; 5, 6, or 7 per cent. is probably the range on one side or the other from the medium of all the irons in this country; when using hot blast iron, alters the constant in Mr. Hodgkinson's formula to make up for any defect in quality. Hot blast iron being very fluid, is better adapted for small articles than cold blast; it appears to approach the Berlin metal. Would use either hot blast or cold blast iron, but prefers a mixture. Though you may specify that the iron be without cinder, you cannot ensure getting it. Has not found much difference between anthracite and other iron. The large castings for the bridge at Newcastle are of anthracite and hot blast from the neighbourhood. Considers that there is very little difference between the strengths of different irons, and that it can always be made up by varying the constant in the formula. Never met with iron varying 15 per cent. from a standard. Is of opinion that, taking the average of irons in this country, there is a great proximity to an uniform standard; irons vary to a small extent on each side of that standard. Though one iron compared with another may give a great difference of strength, a mixture, for which all engineers stipulate, annihilates these variations. Always adopts Mr. Hodgkinson's formula. Adopts the constant he gives, viz. 25 or 26 with a mixture; if compelled to use hot blast iron, would take 20 as the constant, this number being derived from experiments. Has not the same confidence in hot blast as in cold blast iron, rather from opinion than experiments. Understands that the fracture of hot blast is darker and more carbonaceous than cold blast, which should be a dull lead grey. Generally employs six times the working load to be the calculated strength of a girder, and tests it with a weight equal to two trains of locomotives, or two tons per foot in length. Has added to the bridges built on the plan of the Dee Bridge, three castings corresponding to the lower ones, by means of which the line of thrust is raised above the horizontal line. The deflection of a bridge of 96 feet span so altered was 1·96 inches with 56 tons in the centre, equal to two trains of locomotives; it is rather too stiff; considers that a certain amount of flexibility in a cast iron girder is essential to resist the suddenness of the passing weight; it should yield so as not to convert pressure into concussion. Tests large compound girders to one-third the breaking weight, and small simple girders to one-sixth. Tests small girders with the hydraulic press; large girders, with dead weight, suspended from the centre. Iron clamps holding the bottom flange support the platform for the testing weight. The weight is applied in the centre. In bridges it is applied on one side, but the torsion so created is very inconsiderable and may be disregarded. It is not necessary to test girders with weights applied as in practice; the beams that form the platform rest close to the vertical web. When girders have been tested accidentally in that way, has not found any difference; when two girders are tried by the hydraulic press it is by accident only that the pressure is exactly in the vertical plane. Does not consider that alterations take place in iron bridges from length of time or change of temperature; the engine beam of a Cornish engine, with a 90-inch cylinder, receives a shock 8 or 10 times a minute, equal to 55 tons; has known them work for 20 years without the smallest perceptible change. On the Blackwall Railway, 120,000 trains, each of 12 carriages, have passed over girders of 48 or 50 feet span, and when examined four or five months ago, no perceptible change had taken place. These girders were not made to carry locomotives, and they are doing as near their ultimate duty as girders carrying locomotives. With respect to the question of change in the internal structure of wrought iron, knows of no instance where some important link was not wanting to complete the reasoning; that hammering may produce brittleness in iron is probable but not certain; the connecting rod of a steam engine vibrates at ordinary speeds eight times in a second; one just come into the shop from the Norfolk line has run 50,000 miles; the rod has vibrated 25,000,000 of times; yet, apparently, no change can be detected. With respect to axles, has never been able to come to a conclusion whether the axles that broke were fibrous to begin with. The connecting rod being so much smaller, is more likely to be fibrous; a piece of iron rolled from 1 foot to 20 feet is almost necessarily fibrous; but when rolled from 1 foot to 6 feet it is not necessarily so. Does not believe any change takes place in cast iron. Considers $\frac{1}{30}$th of an inch to a foot may be allowed as the deflection for a girder. Considers the deflection from a moving train to be less than that from one at rest. There may be a lateral strain, but is satisfied that the vertical strain is less. Adopts Mr. Hodgkinson's form of girder, with slight variations according to circumstances. Usually puts two girders under one rail with a baulk of timber between for short spans; in some cases it is desirable to have no top flange. With statical pressure adopts 3 to 5 as the proportion of the top to the bottom flange. The difficulties of casting prevent the theoretical proportion being always the best. In large girders has sometimes adopted Mr. Hodgkinson's proportion of five to one. In some cases has made the top and bottom flange equal; although some part of the metal may be thrown away as far as strength is concerned, it is very useful for other purposes. Has made cast iron girders 50 feet long, but now limits them to 40 feet, and then uses wrought iron. For small spans almost invariably uses two girders, with a baulk of wood between, under each rail; it is a convenient way of disposing of the material and getting sound castings, and they are easily handled. They are being used at Penmaen Mawr, where there were 19 spans of 35 feet each. The timber forms a cushion for the rail. In bridges beyond the limits of cast iron girders considers that girders formed of separate castings, with a tension rod along the bottom is as good a form as any; but considers that there is this advantage in having the tension rods at an angle, that you can bring the tension of the wrought iron into play so easily. When such a bridge is wanted on a large scale, the vertical elevation might be divided. When the joints are planed and fitted accurately, such a girder would be as secure as a solid one, as in a large mass the contraction from cooling is liable to be unequal. Has tested compound girders without any bolts and depending on the tension bar, and also without the tension bar but depending on the bolts. The extension of tension bars with 10 tons per square inch is $\frac{1}{1000}$th of the length, and the iron comes back to its original state. The piston rods of Cornish engines go on without being lengthened. Tension rods will not permanently suffer as long as the strain is within the limits of elasticity. With respect to the tension rods in the Dee Bridge which acted at an angle, does not allow the objection that with deflection they might become slackened, but would undertake to break the tension bars by putting on a strain, and that the girders can be cambered by them. Would use wrought iron girders over spans where there was no limit as to expense or levels. Thinks that a bar of wrought iron cast into the bottom flange of a cast iron girder might be too intimate an union on account of the different rates of expansion of the metals; if, however, the proportion of cast iron to wrought was very large, it would not be of so much consequence. It is much the same as bolting a wrought iron bar to the bottom flange of a girder. Does not consider that the vibration and impact to which railway bridges are subject would injure the bolts and rivets. Has observed one or two instances when oscillation was produced on skew bridges when the road has not been in good order close to the bridge, and one wheel came on to a solid angle when the other was on soft ballast; generally now brings the two sides square by means of a wooden baulk. In skew bridges, when oscillation is prevented, both girders are subject to the same vibration. The deflection of a girder would not throw the engine into oscillation; the engine moves at the rate of about 70 feet per second, and there is not time. The deflection of the girder is only a small objection. The approach to the bridge causes the danger. Considers experiments on impact and vibration advisable. An ordinary train weighs about five-eighths of a ton per foot in length. Engines are about a ton to a foot in length. Considers wrought iron girders preferable to cast iron for spans exceeding 40 feet, as being more elastic. Found a very marked effect from introducing a cast iron top in the box girder in the Chalk Farm Bridge. Considers a collection of facts would be very valuable, but any legislative enactment, with reference to the construction of bridges which would hamper engineers, would be very objectionable. Attaches very little importance to vibration, and considers it of little consequence for girders to be laid on ordinary walls without interposing medium. Considers suspension bridges very little applicable to railways; indeed, with the prospect of increasing weights, totally inapplicable. Thinks Dredge's principle scarcely applicable with heavy weights. The more ties they have to the platform the better. Has been informed that a train passing over a suspension bridge at Stockton of 300 feet span caused a wave 2 feet high like a carpet. Understands that American engineers have given up lattice bridges entirely; they soon rack themselves to pieces; the timber is cut into slices instead of being in lumps. The thin bars of an iron lattice bridge make it impossible to convey compression through them; it is "wabbly." Sir John M'Neill has remedied the want of power to resist compression by putting a cast iron top. Exhibited drawings of the wrought iron girder for the Chalk Farm Bridge, with a cast iron top to resist compression. The method adopted to strengthen girders on the Dee Bridge plan, and girders with tension rods along the bottom flange for bridges over the River Arno. Also an experimental girder, similar to the Dee Bridge girder, from which it appeared that the tension rods when acting at an angle could camber the girder. Girders are made in separate pieces on account of the difficulty of cooling large masses, and the inconvenience of conveying them. Thinks it would be imprudent to make larger castings than those recommended for girders. Has had failures. Although there is a considerable variation in the strength of iron, there is a remarkable approximation to an average standard. Practically an engineer is not justified in going to any great expense to get a particular quality of iron. A difference of 20 per cent. in samples of iron is not of much consequence when the girders are made to bear six times the load that comes upon them. Does not consider that any injury can arise to a girder from the bending of the joists supporting the platform; in many cases has had the bearing secured close to the central web. Prefers, instead of depending on one girder, having two bolted together, with a baulk of timber between. Prefers a wooden platform to one resting on iron beams; does not apprehend danger from the vibration, but the noise is so unpleasant that some soft medium should always be interposed.

Joseph Locke, Esq., M. P., Civil Engineer.—The strength of iron will depend upon mixtures. Prefers a mixture. The mixture of hot blast iron with cold blast considerably increases the strength. Understands that a mixture of wrought iron with cast adds to its strength. Considers it better to trust to the knowledge and experience of iron founders of high character than to specify for particular mixtures. Has generally made the breaking weight of girders from three to four times the greatest load; but the load is supposed to be dead weight, whereas the shocks in railway bridges may increase it to within half the breaking weight. On railways from the levels the most convenient form of girder must sometimes be adopted in preference to the stiffest. Would not prove a girder with more than double the greatest load. Thinks dead weight a more self evident mode of proving girders, but that the hydraulic press is a very convenient and good mode. Resting the weight on one of the bottom flanges produces torsion to some extent. Thinks it might be desirable in some instances to test the girders with weights applied as in practice. Has known cases where the test was applied to one flange as in railway practice. Never knew a flange break off a girder. To prevent the girders getting out of the perpendicular, makes the baulks supporting the rails fit tight between the girders, and connects the bottom flanges by the rods. Has never observed any injury arise to girders from being subjected to permanent weights for a length of time, or to changes of temperature. Would allow girders on railway bridges to deflect from the $\frac{1}{50}$th of an inch to the $\frac{1}{30}$th of an inch per foot linear. But the amount would depend on the form of the girder. Some forms admit of more deflections than others. Does not like too much deflection in a railway beam. For the forms of girders adopts the large bottom flange. According to his present experience, would limit cast iron girders in one piece to 45 feet long, but he may perhaps go further. Would always prefer an arch if possible. Dislikes cast iron in flat girders at all times and in all spans. Would never use it if he could avoid it. Does not object so much to wrought iron, but would not use that when it could be avoided. Is not favourable to girders combined of separate pieces. Would use the bowstring bridge for large spans. Does not approve of combining wrought and cast iron as done in girders of the Dee Bridge class. But does not wish it to be inferred that there is no combination of which he would approve. Objects chiefly on account of the different rates of expansion of wrought and cast iron. Does not think that in compound bridges well put together the vibration and impact from trains would affect the joints and rivets; but if badly put together, or the roadway were not in good order, the joints would sooner or later be affected. Does not consider that the deflection of one girder before that of the other in skew bridges would produce oscillation to any injurious extent. When the roadway is good there is very little difference between the deflection due to weights at rest and that due to the weights moving with velocity. A bad joint is much more serious than an increase of velocity. Has known the deflection to be less with velocity. When there is any great difference, attributes it to bad joints. Conceives that perpetual concussions might change the texture of wrought iron. Does not think the same effect would be produced in cast iron. A cast iron beam which had been in use for a long time in the Blackwall Railway was taken out and broken; it bore a very large weight with reference to its calculated breaking weight. Would observe that axles broke more frequently when crank axles were in use. The fractures he has seen appeared to be the work of time. He has seen nothing in the fractures to induce him to believe they were the result of a change of structure. Considers one ton per foot in length as the greatest weight that comes on railways; is opposed to increasing the weight of engines. Thinks the plan of having wrought iron box girders a very sound one. They have been long in use for steam engines; prefers them in moderate spans to cast iron. Would never employ a flat girder unless compelled to do so. The effect of the vibration of trains, however slight, is ultimately to separate the parts, while in an arch the parts are always clinging faster together; if a general rule is to be adopted, let it be in favour of the arch.

Charles H. Wild, Esq., Civil Engineer.—In testing the compound girders for the bridge over the Ombrone, an initial strain of 5 tons per square inch of section was put upon the wrought iron ties; by the adjusting pieces, any amount of initial strain can be put on the ties. By that means the beam can be cambered. If, in compound girders, the ties are applied in a neutral state, they are of very little practical use. The ties have an initial strain put upon them, but does not believe that any change will take place in the ties to require re-adjustment. If the strain put upon them is far within the limits of elasticity, they will retain that strain. If an extension of the ties were likely to take place, this sort of bridge should be given up. The ties being strong enough to allow for extra weight to come upon them, will never require to be adjusted after being put up. The bridge over the Arno is of compound girders, with the ties lying horizontally along the bottom flange. The ties are in four pieces, and adjusted to the required initial strain by means of gibs and keys at the junctions. This bridge was tested by taking out the dowels connecting the castings, and allowing the whole strain to come on the tension rods. If the ties are put on in a neutral state, the elongation when the weight comes on is so small that the strain would only be about 1½ ton per inch; the initial strain can be so adjusted that the tie can take the whole of the tensile strain of the girder, or half, or any proportion. The bridge is 96 feet span, and was tested with 40 tons in the centre, trusting entirely to the ties. Has experimented on compound girders with the tie, and when the tie was removed, and has found the stiffness increase with the amount of initial strain put upon the ties. In breaking compound girders, never saw the bolts give way; no strain can come upon them so long as the joints do not open. Looks upon the dowels and bolts as only useful during the course of erection. Would not like to test the Arno girder without the tie, but thinks the bolts and dowels might be taken away without interfering with the strength. In an experimental girder made for the tie to be adjusted, either horizontally or at an angle, like in the Dee Bridge, it was found to be almost equally efficacious in three different positions—viz., when the ends were, 1st, higher than the top flange of the girder; 2nd, level with the top flange; 3rd, horizontal. The effect of the difference between the extreme cold of winter and the extreme heat of summer would be to add about half-a-ton per square inch to the existing strain upon the tie. The useful effect of the tie, when the girder is bearing a load, depends on its area, upon the strain upon it per square inch, and upon its depth below the centre of compression; hence, if the ends of the girder came in so as exactly to counterbalance the extension of the lower part of the girder (a point never reached in practice), if there were an initial strain on the tie, it would still be doing useful work. It is a popular fallacy that there is a disadvantage in having the ends of the ties above the top flange; the raised ties give greater facility for putting on the initial strain than the horizontal ones. The initial strain is measured by means of an instrument called an extensometer, fixed on to the tie bar, which shows the actual amount the bar is extended; and having found the rate at which similar iron extends with certain weights per square inch of section, the strain on the bars due to the extension is known. The higher the tie is put the less increase of strain comes on it from the passing load. Has never known the tie slacken. Does not consider that a wrought iron bar cast into the bottom flange of a girder is a good method, as no initial strain can be put on it. If, by means of the weight, the bar was extended the $\frac{1}{1000}$th of its length, there would be a strain on it of 10 tons per square inch, but has never known them extended beyond $\frac{1}{4000}$th; hence the strain would only be 2½ tons per square inch. The cast iron would break before the tie was doing much work. The above forms of trussed girder are the only ones that have been adopted. Would have the platform of a bridge firmly united to the girders, and sufficiently deep to prevent any twisting in the main girders. The bearers for the platform in the Arno bridge are Sandwich girders. Mr. Stephenson is using strips of wrought iron, with timber between, for purlins for roofs. They are very stiff.

Thomas Cubitt, Esq., Builder.—Has found variations in the same description of iron; experiments by different persons do not give corresponding results from similar makes of iron. Does not trust to experiments made on a small scale. The quality of iron is only affected by the hot or cold blast so far as materials unfavourable to the production of good pig iron are present. Care should be exercised in the selection of hot blast iron. Makes girders strong enough to bear three times the greatest load that could come upon them; these girders are for buildings. Proves girders by the hydraulic press; proves them to double the greatest load that could come upon them, or two-thirds the breaking weight. From the liability of girders to internal flaws, would rather prove a girder nearly to the extent that would break it than not prove it at all. In buildings, the weight is more frequently put on the bottom than on the top flange, but has never thought it of importance to apply the proof weight to the bottom flange. The deflection of a girder depends on the shape, section, and quality of metal. In two girders, the length of one being double the length of the other, but the section and depth being constant, the longest girder would deflect four times as much as the other. Considers the stiffest iron best for steady weight. Weighted a girder with a load equal to two-thirds of its breaking weight, and left it on for 36 hours; the deflection did not increase, and the permanent set was not more than that which had been observed after the first application of the weight. Makes the area of the top flange to the bottom one as 1 to 3½ or 4. The bottom flange is equal in width to about half the greatest depth of the girder; diminishes the depth of the girder at the ends to about half the depth in the centre; considers it of great importance not to do anything which would tend to make the girder unsound when cast, or cause unequal strains in cooling. Shoes or sockets tend to create flaws, by allowing dirt and sand to accumulate, and prevent the equal flow of metal. It does not follow that the theoretical form of greatest strength is the best one to adopt. His attention has been principally confined to beams subjected to weights at rest. As weight in such castings is not of so much importance, he is guided in the selection of irons by the market price. Always mixes irons; is inclined to think that good will result from Mr. Morries Stirling's endeavours to increase the strength of iron by an admixture of wrought iron. Thinks the manufacture of iron below the other manufactures of the country; believes that in France they roll out bars heavier than we do. Thinks that, if the plan adopted in Belgium of the manufactures exhibiting qualities of iron every year were followed it would improve the manufacture. Considers that the quality of iron depends, first, upon the raw material, then on the fuel and care in manufacture. Thinks investigation into the manufacture of iron desirable, and that it would be advantageous to offer premiums for the best iron.

Isambard Kingdon Brunel, Esq., Civil Engineer.—Has a preference for the Welch and Staffordshire irons. Endeavours to obtain a small proportion of hot blast iron in mixtures. Does not like a large proportion of hot blast; thinks one-fifth advantageous. Takes the greatest possible load that can by any accident come upon a girder, and assumes that as one-third or two-fifths of the breaking weight: but takes the breaking point lower than it is generally taken. As a general rule, would prove a girder with a load a little greater than the greatest that could come upon it, and examines its appearance under that load. Actual weight is the preferable mode of testing girders. Although, strictly speaking, the same load cannot be borne by a girder when resting on one flange as if applied at the top, on account of the torsion, yet, by endeavouring to bring it as near to the centre as possible, has not perceived any sensible difference. If circumstances made it desirable to construct a girder to carry a load on the flange, at some distance from the centre, it might then be desirable to calculate the strength of the girder; would certainly test it in that manner. Such cases have not been sufficiently frequent to require a special provision. Does not believe that any appreciable difference is caused in the power of resistance of the girder. Considers that, with his form of girder, and with a large dead load of ballast, &c., the torsion is inappreciable. A soft substance between anything that produces vibration and cast iron is advantageous, but wooden sleepers to support the roadway should not be so elastic as to press on the edge of the flanges of the girders. Does not consider that a moderate weight left on a girder will ever injure it. Has not observed temperature produce any effect except expansion and contraction. Considers that no weight, except that approaching the breaking one, will permanently affect cast iron. The deflection of a girder does not merely depend on the length. In a girder 30 feet long, 15 inches deep, would allow $\frac{1}{40}$th of an inch to a foot. The deflection must depend on the form. About half the before-mentioned deflection would be allowed in a very stiff girder. Makes girders of the inverted T-section with a very large bottom web, and swelling at the top of the vertical web. The length of cast iron girders is limited by what would insure a sound casting; at present considers it to be 30 or 35 feet. When girders are required for spans beyond the limits of simple cast iron girders, would prefer not using cast iron at all. Would prefer timber or wrought iron, or both combined. Would apply wrought iron to increase the tenacity of cast iron framing. Has adopted that method in machinery. In large spans, assuming there is no difficulty in obtaining an abutment, would prefer cast iron in the shape of an arch. Does not think that in a work put together by a good mechanic, with ordinary judgment and proportionable strength, that any vibration would affect the bolts. Considers that the introduction of wrought iron plates into the construction of bridges is the most important step that has lately taken place in engineering; believes that with ordinary care and the improvements which have been introduced into riveting, that the joints may be equal to the other parts of the structure. Does not think that vibration can have any effect on well-made riveting. Rivets should not act as pins or bolts, but like clamps, and hold the plates together by the friction of the one on the other; in that manner the plates may be insured not to break in any part contiguous to the rivets. Considers that the crystalline fractures observed in bars broken by a succession of blows is not the consequence of any internal change in the metal, but that iron breaks with a crystalline or fibrous fracture according to the circumstances under which it is broken; produced several pieces of iron broken, some with a crystalline fracture by a short sharp blow, others with a fibrous fracture by means of a slow heavy blow. The same effects may be produced by varying the temperature of the bar. Considers that when the rails are well laid the deflection will be less from a moving weight than from that weight at rest. Some new engines weigh as much as 35 tons, and occupy a length of 26 feet or 1¼ ton to the foot run. Believes that cast as well as wrought iron varies its strength with the temperature; the colder it is the easier it will break. Thinks that suspension bridges might be applicable to railways. Has once proposed one under very peculiar circumstances. Considers the Indian tension bridge inferior to ordinary suspension bridges. Would only use a lattice bridge when he could not get materials for the component parts exceeding a certain length: if he were obliged to make a bridge of great length with short sticks, it might be one mode of meeting the difficulty.

Edwin Clarke, Esq., Civil Engineer.—Has superintended the Conway Bridge for Mr. Stephenson. It is a wrought iron tube made of boiler plates riveted together as in iron ship building: the span is 400 feet, the extreme depth at the centre is 25 ft. 6 in., breadth 15 feet; the internal breadth and depth are 21 ft. 8 in. and 14 ft. 3 in.; the depth at the ends is 3 feet less than at the centre. It was constructed on a timber platform on the beach of the river Conway, 200 yards from its permanent site, and was floated to its position on six pontoons of 350 tons each, and raised 17 feet to its position by hydraulic presses; its weight is nearly 1,300 tons. It has a bearing at each end of 12 feet, and rests on bed plates and rollers to allow of its expansion from change of temperature. It was commenced at the beginning of 1847 and finished in March 1848. The original idea arose from considering whether a beam could be made large enough to cross a span of 450 feet. Mr. Stephenson had formed beams of separate pieces united by bolts, and had also applied tension rods to some beams formed of separate castings. A cast iron arch was proposed but abandoned, partly on account of interference with the navigation of the straits. Two beams side by side with an ordinary upper and lower flange would make a space, through which if large enough a railway carriage might pass. The first experiments were on round and oval tubes; they changed their shapes when loaded; rectangular tubes did not; that form was therefore adopted. Experiments were made to determine the resistance of wrought iron to compression, that the actual strength of a large tube might be calculated; the power of wrought iron to resist compression increased as the cube of the thickness of the plates: the strength of the tube varied as the square of the linear dimensions. A model tube one-sixth the real size was made at Mill Wall, and broken five or six times, and strengthened at the part it had broken at after every time, till it was considered that the strength was everywhere proportioned to the strain. The thickness of the sides of the tubes appeared to produce very little comparative effect. The difference of elasticity rendered it difficult to apply cast iron to the top of the tube. A bar of cast iron yields twice as much under the same weight as a similar bar of wrought iron, though its ultimate resistance to compression is four or five times as great. If the top of the tube were made partly of wrought and partly of cast iron, the wrought iron would have to bear more than its share of pressure. Cast iron must also be cast thick, which increases its weight, and the places of junction require heavy flanges. The Mill Wall model it was assumed, if increased to six times its linear dimensions, should be 36 times as strong and 216 as heavy. The bottom of the tube was considered as a chain, and the plates were lapped over to make the chain as strong as possible; the rivets were proportioned so that the section of the rivet to be sheared through equalled the section of the plate it connected. The shearing strain of a rivet is as its tensile strain. Cells were put in the bottom of the tube as being the most convenient way of getting sufficient area of section of iron. The cells are kept stiff by angle irons. There are five rows of cells in the bottom of the tube. The bottom has great strength to resist lateral pressure, as the wind. The sectional area of the bottom is to that of the top as 5 to 6. The area of the bottom is 508 square inches; the area of the top 608 square inches. In the small experiments the top had always failed by buckling, but the strength of plates to resist buckling varied as the cube of their thickness, and the top might therefore in the large tube have been of the same area as the bottom; but as the top had always been the part to fail, and the data for calculating the resistance to compression were not so complete as those for the resistance to tension, a little was added to the top; 12 tons to the square inch is as much compression as wrought iron can be safely subjected to. At 10 tons per square inch most iron begins to be perceptibly altered in shape. The first experiments were made before February, 1846. The last Mill Wall experiment was made in April, 1847. The sides of the tube were considered a mass of trellice work so thickly interwoven as to become a solid plate; at every 2 feet two pair of angle irons were placed face to face, and running from top to bottom of the tube, one inside and the other out, like vertical pillars, to keep the top and bottom apart. The side plates are 2 feet broad. These pillars appear to give sufficient rigidity, as the sides of the tube have never exhibited the least alteration of shape. For a distance of 50 feet from each end vertical plates have been added to strengthen the sides, where the strain was considered greatest. At the ends, to prevent any crushing of the sides, strong cast iron frames have been inserted. The side plates in the centre are half an inch thick, but towards the ends $\frac{10}{16}$ths of an inch thick; the bottom plates are half an inch thick in the middle, and a quarter inch thick at the ends: on the principle that the strain on the bottom varies at each point as the rectangle of the segments into which the tube is divided at that point. When the side of the model tubes were thin near the ends, they invariably buckled there. The resistance of the top cells to compression was never exactly ascertained; wrought iron will not bear above 12 tons compression per square inch. The first cells experimented on were oval; the square and circular were then tried; the iron when thin puckered, but a certain thickness of plate answered equally well to prevent the cells either oval, circular, or square from buckling, and the iron crushed. The cells were made square not because the square form is best to resist compression, but because there were many difficulties in fitting a circular cell in the top of the tube, and lateral strength was wanted to resist the wind, and also all the parts could be more readily got at; the cells are 1 foot 9 inches square, and the plates three-fourths of an inch thick. As regards tension, rivets weaken plates, but rivets increase the strength of plates to resist compression. Plates riveted together generally break at the rivet, though they derive some strength from the rivet acting like a clamp. The top is a plan of pillars and cells; the section is greater in the centre of the tube than at the ends on account of the greater strain. Found a difference in the wrought iron from different makers. Some irons stretch more than others, though the ultimate strengths are about the same. The ultimate strength of the iron to resist tension averages 20 tons per square inch. A great deal depends on the manufacture of iron; some of the iron is very brittle, but its ultimate power to resist tensile strain is as great as more ductile metal. A twelve-ton press laid on the top of the tube produced no deflection of the iron, and a twelve-ton press fell on the top from a height of 25 feet, and produced no other effect than indenting the place where it fell. The locomotive does not run on the bottom cells, but the rails are on sleepers, supported by transverse plates 6 feet apart; the bottom is very rigid. When the wedges were being taken out to let it take its final bearing, the wedges over a large portion of the centre had been left in by mistake, and it was supported by the bottom being bulged up, which was a very severe test; it did not belly up above 1 inch. The tube weighs 1250 tons without the end castings. When the tube was on its original platform, a straight line was set out along the instrument with a thirty-inch telescope, and holes drilled through. The tube was constructed with a camber of 7 inches, that the deflection might not be unsightly. The deflection is sensibly affected by changes of temperature. The motion caused by a cloud passing over the sun, or a shower, was quite visible by the means of an index. The whole structure was a rectangular tube, 412 feet long, before it was moved to its position; it was floated to its position. When raised, 6 feet at each end were added; the bed for it to rest on was 3 inches of creosoted deal, a bed plate 3 inches thick of cast iron, then another layer of creosoted deal to prevent corrosion, a mass of red and white lead was spread over the timber, one end is thus a fixture; the other is on a bed of iron, which rests on 44 rollers of cast iron, 6 inches diameter, to allow of expansion and contraction. In addition to this, to prevent the sides being injured, the tube is partly suspended by suspension rods riveted to the tube at each end, which pass through girders bearing on metal balls, running in grooves; it is calculated that one-third is suspended, and two-thirds on the rollers. The side of the tube is quite closed. The Conway and Britannia Bridges are on similar principles; the Britannia Bridge has 60 feet more span. The Britannia Bridge is named after the Britannia Rock in the Menai Straits. There is one tube for each line of railway. The calculated deflection of the Conway Tube was about 7 inches, so the tube was cambered to that amount. It actually deflected $7\frac{5}{8}$ inches by its own weight. When tested with 330 tons it deflected to $10\frac{1}{8}$ths inches below the original line; on removing the weight it returned to rather more than 8 inches. Probably some rivets had been disturbed. The effect of temperature was found to be very great. The deflections taken at night differed from those taken in the day time. The expansion of the cells at the top causes it to rise. It is painted of a light colour to increase the radiation. The extremes of temperature cannot have an injurious effect, as the motion is only 2 inches over 400 feet span. In raising the tube the strokes of the hydraulic presses became isochronous, and the tube vibrated like a shrinking plank, so that the presses had to be stopped. A train of 100 tons causes three-fourths of an inch deflection, but no vibration. Persons in the carriages don't perceive that it is a tube. There is no increase of deflection since it has been opened for traffic. The deflection is measured by an instrument attached to the side of the tube. There is tremor when a train passes, but no vibration. It interferes with the reading of a telescope. The tremor cannot be perceived by standing or lying on the tube, it is greatest when a cannon is fired from the top.

J. D. Morries Stirling, Esq.—Has studied the chemical properties of iron. Cast iron in this country consists of iron, carbon, silica, some phosphates, and other admixtures which may be considered impurities. Cast iron from Sweden and magnetic ore is purer; it contains less carbon. The strongest cast iron contains 3 per cent. of carbon; a mixture of hot blast No. 1 and cold blast No. 3 will give that proportion, but it would be better for iron with that proportion to be produced at once from the blast furnace. A small portion of arsenic increases the fluidity of iron. The higher numbers of hot blast irons apparently contain more carbon than cold blast. Graphite is commonly to be seen on the surface of No. 1 hot blast, not so frequently in cold. Chemical analysis gives very little difference between No. 1 hot blast and cold blast as regards the quantity of carbon. It appears to be combined in a different manner; generally, Scotch is the most, and Welch the least, carbonaceous iron; Staffordshire is intermediate. Phosphorus gives the hot short quality to wrought iron. Manganese closes the grain of iron; apparently improves the quality; gives it a more steely character; increases the property of being hardened by quenching. It does not give the elasticity of steel. Steel and cast iron are improved by manganese. Berlin iron owes its fluidity to arsenic. Dark iron is usually weak, grey usually strong, and white brittle; black iron when chilled becomes white, although it must be supposed to contain the same quantity of carbon; as a general rule, colour indicates treatment to which iron has been subjected, and, in some cases only, the quantity of carbon. Would employ colour as a test of strength, but not of chemical constitution. To resist a transverse strain, grey iron (not approaching to mottled) would be best; to resist a blow, grey iron, approaching to mottled, would be best. The East Indian iron has many properties of malleable iron; its mixture with other pig-iron improves the quality of the latter: small quantities are used in the patent boiler tube manufactory to improve the iron purchased for making wrought-iron. The best mixture of iron for strength would be, for a large casting, a larger proportion of No. 3 Scotch, Staffordshire, or Welch; for a small casting, a larger proportion of Nos. 1 and 2, and a smaller of No. 3. Numbers of iron are, however, very arbitrary: mixing iron adds very much to the strength. London founders improve their irons by the use of scrap iron. Ordnance and hydraulic presses are made chiefly of No. 3; for a girder, more fluid iron would be required. Iron cast in large masses becomes soft from cooling slowly. Has proposed to improve cast iron by an admixture of wrought iron. There is a chemical combination between the two. The quantity of carbon is diminished. The grain is much closer. A small quantity of wrought iron added to dark grey iron makes it light grey; a large quantity makes it mottled, a larger still almost white. Scotch iron requires most wrought iron, Staffordshire less, and Welch iron least. The proportion for Scotch hot blast is for No. 1 from 24 to 40 lb. per cwt.; No. 2 from 20 to 30 lb.; for No. 3 it is not recommended, as the iron is uncertain in itself. Staffordshire will not bear so much as Scotch; 20 to 30 lb. would be a high proportion for Staffordshire No. 1. Welch No. 1 bears the same as Staffordshire; No. 2 requires very much less. The increased strength of the iron is an advantage mechanically. From an average of experiments the waste in casting was 7 lb. per ton in favour of common cast iron. The iron planes like wrought iron and the castings are more difficult to trim than those of common iron. The first object in proposing the iron was to raise the inferior irons to a level with the best, but has obtained a mixture stronger than the strongest. The improvement on strong irons is not proportionably so much as on weak ones. It seems to bring irons to an average. By adding wrought iron scrap to pig iron, and puddling it, the resulting wrought iron is much improved. Cast iron easily acquires magnetic power, and acquires extreme polarity without the power of attracting small bodies to the degree that steel does. Considers it an advantage that a beam of toughened cast iron need not be so heavy as that of common iron. Has observed instances of alteration in the structure of iron from repeated hammering, and shafts exposed to vibration also crystallise. Considers that, possibly, galvanic action causes the change. Cold hammering gun barrels too much makes them brittle. The mixture of wrought iron with cast is made originally in the pig. The specific gravity is from 7·2 to 7·3; the specific gravity of common iron from 6·9 to 7·3. The centre of a casting should be taken for the specific gravity. Thinks it would be useful to inquire into the generic differences of irons.

Charles May, Esq, Ironfounder.—The difference in the strength of iron appears to consist mainly in the proportion of carbon. A large dose of carbon makes a very tender iron; the strength appears to be greatest when the carbon is in the smallest proportion that produces fluidity. The greatest mixture of irons is preferred. One-third anthracite combined with Scotch is a good mixture for toughness and strength. For small castings a more fluid iron is wanted than for large ones. On account of competition, the cheapest iron is often preferred to the strongest. With the bulk of Scotch iron combines Welch and scrap iron; the mixture is very much reducible to the quantity of carbon. An iron very hard for small castings would be soft from the slow cooling if run into a large mass. Cast iron does not depend solely upon its constituent parts, but upon the bulk into which it has to be run; these varying circumstances constitute the art of the ironfounder in producing the greatest strength without any very definite knowledge, either chemical or mechanical. By annealing, great toughness can be produced [*produced a shaving taken from the edge of an annealed cast iron wheel*]. Hot blast iron ought to be as good as cold; but, in some cases, advantage has been taken of it to work up an inferior material. Since the introduction of the hot blast the quantity of carbon combined with iron is greater. Has not the same confidence for strength in hot blast as in cold blast iron. Has met with hot blast iron as strong as the strongest iron. The public would have no security in cold blast *versus* hot blast iron. The fact of specifying for a particular quality of iron is almost nugatory; the principle of testing the work when done should be adopted. Knows no certain mode of telling different kinds of iron; the manner in which cast iron is modified by the quantity of carbon it contains is shown by chilling. The main feature as regards iron is a question of the proportion of carbon. Considers Mr. Morries Stirling's mixture very advantageous, particularly for irons too rich in carbon. Would make the breaking weight of a girder three times the greatest load. Considers that railway girders are exposed to severe strains from the new foundations, the violent impact they are subjected to, and the load being laid on and removed suddenly. Would prove a girder to once and a half or twice the greatest load; beyond that there is a chance of damage. Considers that the side strain, from supporting the load on the bottom flange, would prevent the girder bearing as much as if applied on the top. Thinks tests should be applied as the weights are applied, in practice; but girders are bought at the lowest possible price per ton, and ten times the profit would not pay for experiments. Thinks the only limits to the length of simple cast iron girders are practical ones, of handling large masses, and pouring the metal equally to form good castings. If a large number of large girders were wanted, it might be worth while to erect a new foundry for the purpose. Is favourable to wrought iron girders. Considers that wrought and cast iron may be combined so as to produce an advantageous effect. When weight comes on the cast iron the wrought iron should take its share of the load. Considers that, if well made, the joints and rivets of railway bridges would not be injured by the vibration and impact to which they are exposed. Cites the instance of the beam of a steam-engine vibrating continually without suffering any injury, as an instance of iron not being affected by continual vibration; and mentions, in favour of its being so affected, the fact of a gun, employed to break pig iron across, dropping in two after a series of years. Considers the only security for good work is, to hold the makers responsible for it. Has found great variations in bars of similar metal. Thinks that the breaking weight of a small bar is no index to the breaking weight of a large casting.

Joseph Cubitt, Esq., Civil Engineer.—Is at present constructing the Great Northern Railway. Prefers a mixture of Scotch and Welch or Staffordshire and Scotch irons for large castings, as mixtures are stronger than single irons. Believes cold blast iron to be stronger than hot blast iron. Would make the breaking weight of a girder six times the greatest load. Proves a girder with three times the greatest load likely to come upon it, or half the breaking weight. Proves girders either with the hydraulic press or with dead weight; strikes them while the weight is on with a large wooden mallet. Does not consider a girder would bear so much weight if applied on one of the flanges as if applied at the top; prefers loading the girder at the top if possible. Considers the proportions he adopts as sufficient to compensate for the torsion. Has often tested girders with the load on the bottom flange. Has two girders for each line of way, and supports the rails on wooden bearers. Considers any elastic substance between the rails and cast iron girders of advantage in preventing shocks. Does not consider it likely that girders would increase in deflection after a length of time. Would not like a girder of 40 feet span to deflect more than ¼ inch; those he is putting up will not deflect half that amount. Observes the deflections of girders when testing them. Adopts Mr. Hodgkinson's form of girder, but makes the top flange rather larger, to give lateral stiffness. Would not like to go beyond 50 feet for the length of simple cast iron girders. Beyond that span would adopt timber, wrought iron, or the bowstring bridge. Has crossed spans of 100 feet by timber bridges and by wrought iron tubes. Considers a bowstring girder with a cast iron bow and wrought iron tie a very good combination of wrought and cast iron. Would prefer wrought iron or timber. Would use an arch of cast iron if not limited with respect to expense or levels. Does not consider the impact and vibration to which railway bridges are subjected sufficient to injure the joints and rivets. In wrought iron hollow girders take the depth at $\frac{1}{15}$th of the span. Subjects them to the same proof that he does cast iron. Does not observe that they acquire any permanent set. Has put some up at Doncaster of 70 feet span. Has found no difference between the effect produced by a weight at rest on a girder and that due to the weight moving at a velocity over it. Considers the greatest weights running on railways to be engines, they weigh 25 and 30 tons. Something more than half the weight of the engine is on the driving wheels. Has preferred for a viaduct near Welwyn, on the Great Northern Railway, brick arches to iron girders. Approves of the wrought iron girders used in the large spans on the Blackwall Railway. If kept painted they will last for a long time; in some cases, to prevent torsion, a cross piece of cast iron between the tops of two girders is advantageous.

SUPPLY OF WATER TO THE METROPOLIS.

We promised to give an account of the different projects which are now before the public for the supply of the metropolis with water, of a better quality and in larger quantities than the supply now given. There are five schemes—namely, 1st. The Henley; 2nd. The Mapledurham; 3rd. The Watford; 4th. The Wandle; and, 5th. The Kingston.

With regard to the Henley and Mapledurham schemes, there has just been issued a very able report made by Mr. James Walker, the eminent engineer, and Mr. Stephen William Leach, the engineer and surveyor to the Corporation of the City of London; and another valuable report on the Watford scheme has just been made by Mr. S. C. Homersham, the engineer to the Watford Company.

It is not our intention to go into the question as to whether the supply ought to be left to private enterprise or to commissioners; but we must now say that generally we are advocates for the former, and have great aversion to public commissions—particularly if we are to have such a board as is proposed to be constituted by the Henley Bill, than which we cannot conceive one more objectionable could possibly be formed. The Commissioners are to consist of persons to be elected, yearly, by the ratepayers of the several Unions of the metropolis, one for each Union; and these Commissioners are to elect a Commission of seven persons, who are to take the entire management of the concern, and are to receive for their labours the sum of £7,700 per annum between them, out of the water rates. By this mode of election, we are to have the metropolis constantly agitated for all the rated inhabitants of the different Unions to muster together, and go through the farce of electing one Commissioner who is only to be a delegate to elect another representative; and to this irresponsible Commission of seven persons, liable to vary every year, is to be entrusted the outlay of two millions sterling. With regard to the amount of the water rate, there appears to be no limit as to what it will be;—first, the Commissioners will have the power of charging *three pounds* per centum per annum on the annual rack rent of the premises; and, in addition to the said maximum rate, the Commissioners are to have power to charge a proportionate part of whatever sum they may be yearly liable to pay, whether for interest or annuities upon moneys borrowed to pay for the purchasing of the undertakings of the existing water companies.

We have made these remarks on the proposed Henley Act just to show that the scheme can never be allowed to be carried out under such an ill-advised Act. The Act, or rather the Bill, appears to have been drawn with a judgment very different to that shown in the getting-up of the engineering department, which we must say exhibits great labour, great talent, and great judgment.

It appears to us that it will be far better for the House of Commons to appoint a select Committee of the House, first, to examine the different schemes that are proposed, without regard to the Bills to be brought in for the regulation of the supply, and to report to the House which they consider is the best; and whether the supply for the whole of the metropolis shall be confined to one of the schemes, or whether it will not be advisable to have one for the North of the Thames Westward of the City, another for the City and Eastward, and another for the South of the River: by thus dividing the supply, there will not be that great diversion of the waters of the Thames from one portion of the river, as stated in Messrs. Walker and Leach's report.

Looking at the whole of the case impartially, we cannot see why the enormous expenses of forming the New River cut, and all the works connected with that Company, should be lost to the public, a supply might be obtained from the New River head at Chadwell, and the river Lea above Tottenham, quite equal to the supply to be taken from the Thames at Henley or Mapledurham. To do this, it will be necessary to obtain powers to divert the drainage from the land and houses on each side of the cut, and prevent the river from being contaminated. By adopting this scheme, one-fourth of the supply of the metropolis might be confined to the City and the Eastern district; and this would be done without affecting the river Thames.—If this be granted, the consideration will next be which of the three schemes, the Henley, the Mapledurham, or the Watford, is the best for supplying the North-Western district of the metropolis.—For the supply of the Southern side of the river Thames, we have the Kingston and Wandle schemes. The former is put forward with the view of taking the water from the Thames above Kingston, and beyond the influence of the tide; and the latter proposes to take its supply from the Wandle just before the water is discharged into the river Thames; and as the discharge is within the influence of the tide, the withdrawal of the water from that part of the Thames (at Wandsworth) cannot much affect the river, particularly if the supply be confined to the Southern districts.

Having said thus much, we shall now proceed to describe the works of the several schemes. For the Henley and the Mapledurham works, we cannot do better than give the valuable report of Mr. James Walker and Mr. Leach.

No. I.—*The Henley Works.*

The first in point of date is the Henley scheme, notices for which were given in the last session of parliament, but the bill was lost upon the second reading in the Commons, after a debate of some length. As some modifications have since been made we shall confine our description to the plan now proposed and deposited.

It commences by an aqueduct which branches off from the river Thames near Mednunham Abbey, or about four miles below Henley. In its course to London it is first by an open canal 40 feet wide and 10 feet deep, as far as West Drayton; thence 26 feet wide and 7 feet deep, to the river Brent; and thence by two brick culverts, each 10 feet diameter, to West-end, Hampstead.

At Hambledon lock, which is about two miles below Henley, there is a lift or rise of three feet six inches in the navigation. This lock is to be removed, and one erected below Mednunham Abbey, the point of junction of the aqueduct; so that the part of the river between the new lock and the lock above Henley will form a nearly level pool or reservoir, five miles in length, and 88 feet above high water.*

From Mednunham the course of the aqueduct curves round the foot of the high ground, and approaches the Thames below Marlow, proceeds on to

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* By high water is always meant the high water of an average spring tide near London, or Trinity standard.

near Cookham, is carried over the Thames by an aqueduct bridge about a quarter of a mile above Maidenhead-bridge, keeps nearly close to the Great Western Railway as far as Bull's-bridge, a length of 13 miles, and for nearly 10 miles by the sides of the Grand Junction and Paddington canals, passes under the Grand Junction Canal at West Drayton, and twice under the Paddington Canal westward of the London and North-Western Railway; the aqueduct then continues through Willesden, under the Edgeware-road, and on to West-end, Hampstead, where it terminates in a large basin. The whole length from Mednunham to Hampstead basin is 33½ miles.

Three large collecting and settling reservoirs, for cases of drought, or of the water being discoloured by land floods, are proposed in the line of the aqueduct: one near Cookham, another near West Drayton, and the third, of 77 acres, near Harrow.

From the Hampstead basin, in which the water will stand 85 feet above high water, it is to be raised by steam power (3,500 horse) into an elevated reservoir, also at Hampstead, which is 250 feet above high water. From this last reservoir large iron mains, extending in various directions on the north side, and over Vauxhall-bridge to the south side of the river, will be connected with and supply the mains and pipes in all the districts of the present water companies, whose works are henceforth to belong to the commissioners of the new works, the shareholders of the old companies being compensated by a fixed interest upon their capital.

The inclination or fall in the surface of the water from Mednnnham to the Hampstead basin is calculated by Messrs. M'Clean and Stileman and Mr. Blackwell, the projectors and engineers of the plan, to be sufficient for conveying from the river 200,000,000 gallons in 24 hours as far as West Drayton, and 100,000,000 thence to Hampstead. This last being the quantity supposed to be required for giving "an ample daily supply for the metropolis," is stated to be at least double the present supply by all the companies.

The object of the large aqueduct as far as Drayton is to pass a quantity, when there is surplus in the Thames, into the Grand Junction Canal, and thence into a reservoir at Paddington, 85 feet above high water, whence it will be conveyed into the sewers of London for the purpose of cleansing them. The large addition for the purposes of sewerage would lead to an increased expense if any of the schemes for pumping up the water after passing through the sewers be adopted.

The engineer's estimate is:—

Works for bringing water from Henley to London, including compensation to millowners	£1,000,000
Cost of plant for distribution, in addition to the plant of existing companies	1,000,000
	£2,000,000

And the annual expense as under:—

Rentcharge, as compensation to proprietors of existing companies..	£127,500
Cost of distribution, independently of interest of capital for plant	100,000

No. II.—*The Mapledurham Scheme.*

The other, or Metropolitan Water Supply Company, which has been brought out during the last summer by Messrs. Gordon and Liddell, engineers, proposes to take its supply from the river above Mapledurham lock, which is five miles above the junction of the river Kennet, near Reading, or 17 miles (by water) above Mednunbam (the Henley Company's point of abstraction), in which distance there are five locks, the united lift or rise 24 feet above the Mednunham proposed level. An open cut or aqueduct, four and a half miles long, is to convey the water from Mapledurham to Caversham, where four reservoirs, together 100 acres, and 98 feet above high water,* are to be formed for purifying the water upon Dr. Clarke's patent process. Powerful steam-engines are to raise the water from these reservoirs through three iron pipes, each five feet diameter, carried across the river, and then into three smaller reservoirs, at one mile distance from the Caversham reservoirs, and 35 miles from London, and at different levels, corresponding with the levels of the three districts into which the engineers suppose London to be divided—the northern or western district being taken at 120 feet; the centre district, which comprehends the City, at 70 feet; and the south and east district at 10 feet above high water. The highest of the small reservoirs is 233½ feet above high water mark, and the lowest 178½ feet, the mean lift being 100 feet, which will require 1,100 horse-power. The water is conveyed from the small reservoirs by a continuation of the three 5-feet pipes to the Great Western Railway, near Twyford, whence they are laid by the side of the railway, and pass over the Thames at Maidenhead, over the Grand Junction and under the Paddington Canals to near Wormwood Scrubs; here the high level pipe diverges, and passes under, and then by the side of, the North-Western Railway to a reservoir at Primrose-hill of 3½ acres, and 169 feet above high water. The other two pipes, for the middle and eastern levels, continue from Wormwood Scrubs by the side of the Great Western Railway at Paddington, and thence along Westbourne-terrace and Oxford-street into a reservoir in St. Giles's, of ½ acre area, and 114 feet above high water. The third or lowest pipe crosses the Thames at Waterloo-bridge into the southern district. The three great mains, or town reservoirs, communicate with the pipes of the present companies.

The engineer's estimate for this scheme is—

For works	£1,200,000
Annual working expenses	20,000

We come now to consider the effects of the two plans upon the navigation of the river, and in doing so we do not think it right to confine ourselves to what the parties profess as to the quantity they mean to abstract; for if the whole of London is to be supplied from one source there will be no satisfaction until the supply is ample and constant, whether the source be Mapledurham or Henley; and parliament will naturally take this into consideration, and give a preference, so far as quantity is concerned, to the plan which has the greatest certainty in the above respect.

The present supply by the water companies is stated, in a recent publication by Sir W. Clay, chairman of the Grand Junction Company, to be 44,573,979 gallons per day; so that the quantity has much increased since 1834. This has been caused partly by the increase of population, and partly also by the greater supply to each house. Is it not probable that both the above causes, and the demand for water for sewerage and other sanitary purposes, will continue to operate so as to render it prudent to allow for these in any great plan; and to consider the effects which the greatest probable abstraction would be likely to have upon the navigation? It is, however, to be noticed (and this was one of the objects in our describing the main features in the two plans), that the Henley party propose their works to be made at first for taking double the quantity calculated by the Mapledurham Company; and also that the Henley aqueduct, being chiefly open can be enlarged—if ever this should be required—at less cost than the Mapledurham, who have to raise their water to a mean height of 100 feet and then pass it through 36 miles of close pipe. To increase the number of pipes would add materially to the cost, and to double the quantity through the same pipes would require an increase of power much beyond the increase of the quantity.

To compare in detail the merits of the two plans would require us to survey the lines, which your instructions would not warrant our doing; but having said thus much on what may be considered a superiority in the Henley scheme, it is but proper to add that the liability of an open canal to receive impurities into it, whatever care may be taken to prevent this, and also to be partially impeded by ice, are objections to which the Mapledurham is not subject; and if the salubrity of the water be presumed to depend upon its freedom from organic matter the Mapledurham source would appear to be preferable, as in the seventeen miles between the points of abstraction, Henley, Reading, Wargrave, and some villages drain into the river. On the other side of the question, it is to be noticed that the Loddon and Kennet join the Thames below Mapledurham and above Mednunham.

We propose therefore to calculate on the abstraction of 100,000,000 gallons per twenty-four hours stated by the Henley project, which is exclusive of their taking an equal quantity (except in times of drought) for sewerage, as has been stated.

The termination of drought and commencement of surplus in the river, with the works for regulating the additional discharge, should be determined in a manner to be approved, and afterwards inspected and controlled by you.

Now, the effect which the abstraction will have upon the navigation both of the locked part above Teddington and the tidal part between Teddington and London, being dependent on the proportion which the part abstracted bears to the whole of the river water, we have endeavoured by former measurements taken by the late and present Mr. Rennie, by Mr. Simpson, and now by Mr. Blackwell and ourselves, at different times, to ascertain the natural discharge of the Thames during such a drought as not unfrequently occurs.

At Staines, the head of your district, we consider the quantity may be taken at from 350,000,000 to 400,000,000 gallons per 24 hours; and at Teddington (18 miles lower), in which space the Colne, Wey, Mole, and Hog's Mill rivers join the Thames, at from 500,000,000 to 550,000,000: so that, in round numbers, the abstraction near Staines will be one-fourth, and at Teddington one-fifth, of the whole natural discharge of the river. In 1846, a very dry time, it was only 248,000,000 near Staines by Mr. Leach's measurements.

As Mr. Blackwell made the river at Henley, during the shortest water of this year, 345,000,000, it may be fairly supposed that at Mapledurham, which is above the junction of the Kennet, it did not exceed 300,000,000; so that the abstraction of 100,000,000 would be one-third of the whole river during seasons of drought. This is more the business of the commissioners of the upper districts; but if the navigation in their portion of the river be damaged, the effect upon the trade would be nearly the same as if the evil were done in your own district.

To enable us to judge as to the effect of the abstraction, correct sections of the bed of the river, and of the depths and inclinations or slopes of the water in the lengths likely to be affected, were indispensable. We again employed an engineer to complete the levels and sections from Staines to Teddington, which he began in the spring, and Mr. Smith to assist us in the

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* There is a want of agreement in the levels which have been obtained from the engineers

surveys for the sections below Teddington. These have occupied considerable time, and have been made with great care.

[Here the report enumerates the locks and weirs, and specifies the depths upon the sills, &c. It then proceeds to speak of the deposit.]

The diminished water would have the tendency to increase the growth of weeds and the settlement of deposit in all the periods, but we think it would not exceed a tendency, as the water is clear during the times of short water; at any rate, it is not a matter which we can reduce to quantity, and the same observations as to effect will apply to the reduction of depth in the length of the periods, some of which are, like the sills, barely sufficient for the barges, the standard summer drought of which is 3 feet 10 inches, and they often exceed this.

The effect of the tideway below Teddington lock comes to be considered separately. This lock when built in 1810, had 6 feet upon its lower sill at low water in times of drought. The removal of London bridge and the deepening of shoals in the river near London have lowered the water so that there is now only 3 feet 9 inches upon the Teddington sill (a reduction of 2 feet 3 inches), and the reduction would be greater if the shoals between London and Teddington were removed; for although these shoals impede the passage of barges they assist in preventing the water over them and up to Teddington from falling lower, which is one of the causes of their not having been removed by you. In this case, therefore, the river water, which follows the descent or ebb of the tide, is valuable, both as respects getting over the shoals and keeping up the water upon the Teddington lock sill. Mr. Leach has calculated that the effect of abstracting 100,000,000 gallons would be to lower the level of the water at the lock and for a distance downwards 7 inches, which would be a real and practical evil.

It is proper to state that the above evil is not, in our opinion, without a remedy, for by the removal of Teddington lock, and erecting a new lock near Kingston, or about a mile or a mile and a half above Teddington, with a sill of sufficient depth there, removing the shoals so as to enable the tide to flow more freely up to the proposed lock, and deepening the river up to it, the abstraction of water would be compensated for, and the navigation of the Thames improved by the greater quantity of tidal water which would flow and ebb at every tide.

By the removal of the Teddington lock to near Kingston, as above recommended, the drains of that and the low grounds near it would empty into the river below the lock, which would, it is considered, be an improvement to Kingston and the low ground near it. The suggestion for the removal of Teddington lock and of the shoals is not new; all that is meant to be said is, that the proposed abstraction for waterworks will increase the necessity for it. It may be observed here that the scour of the river between Teddington and London is very little affected by the sluggish current in times of short water, but is chiefly due to the influence of land freshes, during which the discharge is from four to six times greater. Mr. Leach made the quantity below Staines during the flood in 1848, 1,600,000,000; the Henley abstraction of 200,000,000 would therefore still form a considerable proportion (one-eighth) of the whole discharge even in times of flood. If it be asked whether, if the above improvements, by taking down Teddington lock, were made, and the whole of the river water at the same time preserved, matters would be still better, our answer would be in the affirmative; but it is not to be lost sight of that the object of an ample supply of good water is a very important one, and that if it can be shown that London is not so supplied at present, but that it would be by either of the two plans under consideration, the damage which the navigation would suffer would be but small if the means for lessening it which we have referred to were adopted: and we cannot suppose that the parties who were promoting the water supply would be unwilling to carry into effect the measures that may appear reasonable for preventing injury to the navigation through these operations.

The engineers of the two plans agree that the season of drought will be prolonged by these works, and that the evil of such a drought will be increased. Messrs. Gordon and Liddell propose a remedy by means of moveable weirs. We think that a more simple one may be applied in your district; but as the evil is agreed, we do not apprehend there can be much difference of opinion as to the remedy. It must also be admitted that by the substitution of tidal for river water in a part of the river the quality of the water will be less pure than at present.

We have not all referred to the numerous other new plans for supplying London from other rivers and sources, although we understand that notices have been given for some of them, which we were not, until very recently aware of, our instructions not having specified them. Our present impression, however, is that none of them would furnish that abundant supply which we are disposed to consider indispensable, if a general reform, or rather revolution, is to take place in the present system of water supply. As to the effect of these plans upon the navigation, if the water be taken from the Colne or any other river that falls into the Thames, which is the great drain and recipient of all the springs in the strata that incline towards it, the effect is injurious in a greater or less degree, according to the quantity and the distance up the river at which the abstraction may take place.

We beg to conclude by stating that the Grand Junction, the Chelsea, the West Middlesex, and the Lambeth Water Works, all take their water from the Thames, so that the new plans would be partly a substitution and partly an addition, but the present companies' supply is from places so low down the river as to be comparatively harmless. This character, however, would not apply so fully to the Lambeth Company, when their power to take 20,000,000 of gallons per day from Thames Ditton, which is above Teddington, shall be carried into operation; and it is natural to suppose that although the present companies take water from the river so low down as to be less injurious to navigation than either of the present schemes, the tendency will be to follow the example of Lamheth in going higher in order to silence the complaints of their customers as to the quality of the water now furnished.

No. III.—*The Watford Project.*

This project has for its object the taking of the supply of water direct from the bowels of the earth, without allowing the springs to overflow into the rivers to be contaminated, or to be discharged into the sea. From experiments made in the years 1840 and 1841, under the direction of Mr. Robert Stephenson, it was ascertained that a well sunk in Bushey Hall Meadows, only 34 feet deep, with four 5-inch borings to the depth of 130 feet, yielded upwards of 1,800,000 gallons per day, which clearly proved, that by more extended works, an immense supply might be obtained. Mr. Stephenson proposed to sink wells to the depth of 100 feet, and lift the water to about 50 feet above the surface of the Meadows; and then to convey the water, by means of a brick culvert, driven through the hills between Edgeware and Bushey, to a field on the north of Edgeware, where a large reservoir was to be formed to receive the water, whence it was to be conveyed by means of large iron pipes, along the turnpike-road to a hill near West-end Lane, where distributing reservoirs were to be formed on three different levels (the highest about 180 feet above Trinity high-water mark), and thence the water was to be conveyed, by means of iron mains, to different parts of the metropolis. These reservoirs were of sufficient elevation to supply all parts of the metropolis. For supplying the high ground about Hampstead, an auxiliary engine was to lift the water from the most elevated reservoir, and force it up to a higher reservoir. By this plan the whole of the water, excepting for Hampstead, was only to be lifted 50 feet above the level of Bushey Hall Meadows. The total length of the work, the culvert, and main pipes from the wells at Bushey to Edgeware-road, corner of Oxford-street, was between 14 and 15 miles. This plan, in our estimation, was more economical than the one now proposed by Mr. Homersham.

Mr. Homersham proposes to lift the water from the well to be sunk at Bushey Hall Meadows, and convey it by iron pipes to two reservoirs to be constructed at three miles distance, on Stanmore Heath, at an elevation of 390 feet above Trinity high-water, the water having to be lifted 200 feet above the Meadows. At Stanmore the two reservoirs were to contain collectively 70 millions of gallons. The water is to be then conveyed from these reservoirs, by iron mains, along the turnpike-roads, to another reservoir (to hold 24 million gallons) to be formed at Child's-hill, near Hampstead, 302 feet above Trinity high-water, and from it a large main is to convey the water along the Finchley-road to Oxford-street; and thence the water is to be distributed by branch mains to various parts of London. The reservoir at Child's-hill commands a district at least 110 feet above the reach of any existing company. Another high service reservoir is to be formed at Stanmore, at an elevation of 490 feet above Trinity high-water, to supply Hampstead, Elstree, Highwood-hill, Totteridge, Harrow, Stanmore, &c. At three of these places other reservoirs are to be formed, making in all seven reservoirs. By distributing the reservoirs they can be supplied from the mains at different times of the day and night. By these works it is proposed to supply the metropolis with eight millions of gallons per day for 40,000 houses, at 170 gallons daily, and leave 1¼ million gallons for wholesale consumers.

The cost of forming these works Mr. Homersham estimates at 340,000*l.*, and the annual expenses at 15,725*l.*, which includes 9,900*l.* as the cost of pumping the water, and the wear and tear of engines, which will make the expense of pumping 2*s.* 6*d.* per annum per house, supplied with 100 gallons per day, which is what we stated could be done.

From our knowledge of the experiments that were made under the direction of Mr. Stephenson, we fully believe that a very large supply of water, of undoubted purity, may be obtained from wells sunk in Bushey Hall Meadows, which will be sufficient for a very large district of the metropolis.

If the works could be carried out as suggested by Mr. Stephenson, and with some trivial improvements, we should have no hesitation in pronouncing the Watford scheme as in every respect the best for the supply of the western division of the metropolis

We now come to the supply of water for the districts South of the Thames:—

No. IV.—*The Kingston Project*,

Which proposes to take its supply from the river Thames, above Kingston, and above the influence of the tide, where settling and filtering reservoirs are to be formed and engines placed for lifting the water; and thence the water is to be conveyed by 30-inch mains to the reservoirs of the Lambeth Waterworks at Brixton.

No. V.—*The Wandle Project*

Is to take the supply from the river Wandle, at the head of the last mill, before the water is discharged into the river Thames, and to lift the water to a reservoir to be formed on Wimbledon Common of sufficient elevation to supply the whole of the Southern districts; and thence the water is to be conveyed by 36 and 30-inch mains as far as the Elephant-and-Castle, and then branch mains are to radiate through the different parts of the district.

For the purpose of preventing the Wandle being contaminated by drainage or any impurities, a sewer is to be constructed from Croydon to the Thames, with branch drains to intercept all the drainage from Croydon and other towns and houses that now drain into the river Wandle, and also to convey the impurities from the different mills: by this means the water of the river will not be contaminated by drainage. It is well known that the water of the Wandle is from the chalk formation, and is of remarkable purity, and was one of the sources proposed by Mr. Telford for supplying London.

We believe that we have gone through the several projects that are now before the public, and it is our sincere hope that Parliament will thoroughly examine the whole, and not allow the supply of water to the metropolis to remain any longer a disgrace to the nation and to the legislature. It is needless for us to enter into the question as to how the present companies obtain their supply, as it has been so ably exposed in the columns of the *Times*, and is unmercifully condemned by the public.

WATER FROM THE CHALK FORMATION.

Sir,—In the December number of your excellent *Journal*, I endeavoured to show that the lowering of the water-level of the wells sunk under London through the blue clay to the chalk, must arise from the condensed and impervious chalk underlying the London clay, and communicating with the Upland chalk, and not from any deficiency of water in the chalk hills surrounding London to the north, west, and south.

This is confirmed by the fact that the chalk under London communicates with an area of more than 4,000 square miles of Upland chalk, barely covered with a porous soil; and that ¼-inch of water in depth per annum over only one-half of this area finding its way under London, would yield 19 *millions of gallons of water for every day in the year*,—while the total amount of water lifted from the deep wells under London at the present time, there is reason to believe, does not exceed 10 millions of gallons per day.

The amount of saline matter contained in the water yielded by different deep wells under London varies, according to Brande,* from 38 to 69 grains per gallon. The base of this saline matter is principally soda, which seems to prove that a large portion of the water beneath the London clay is derived from salt water. As the chalk formation communicates with the bed of the Thames, from Woolwich to Gravesend, and also under the sea, this is easily accounted for by supposing that the water in the chalk underlying the London clay is fed to some extent from this source.

At any rate, it is perfectly evident from the lowering of the level of the water pumped from the chalk below London, when so inconsiderable a quantity is raised, that a very partial communication, if any, exists between the upland water and that procured below the London clay.

S. C. Homersham.

19 *Buckingham-street*, *Adelphi*,
January 26th, 1850.

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* See Quarterly Journal of the Chemical Society of London for January, 1850. Hippolyte Baillière, 219, Regent-street.

SOUTHAMPTON ARTESIAN WELL.

Sir—As artesian wells are now become a subject of constant discussion, and as allusion is frequently made to the experiment on Southampton Common, it may not be without interest to your readers to state the progress and present state of that incomplete undertaking.

Southampton is situated in the centre of the great chalk basin, of which the rim may be traced along the downs of the Isle of Wight, thence under the channel to the Dorchester coast,—from Dorchester through Salisbury to Winchester, and thence to the coast of Sussex.

Leaving geologists to determine—which they seem unable to do—the probability of our obtaining an abundant supply of water, either from the chalk or the green-sand, I shall confine myself to a few figures and facts.

The London clay was reached by penetrating 78 feet from the surface, through alluvial clay, gravel, and sand, the rush of water and loose sand being kept back by an iron cylinder 14 feet in diameter at first, but narrowed, at different stages, to 8 inches, at 465 feet below the surface. The thickness of the London clay formation is 304 feet; it is of all degrees of consistency, from the loosest sand to the hardest stone, abounding throughout in the usual fossils, beautifully preserved. A thickness of 97 feet of plastic clay brings us, at 479 feet from the surface, to the chalk, and into this a 4-inch bore has been carried to an additional depth of 781 feet, without any important increase of water: during the time of pumping, the water continues within 80 feet of the surface, rising to 40 or 50 feet when not interfered with. By pumping from this depth, 30,000 cubic feet daily may be obtained.

The present depth was attained in 1846, since which time the boring has been discontinued. Very lately, however, a contract has been signed with Mr. Clark to continue the boring 300 feet. I apprehend, however, that progress will be stayed until the Report of Mr. Ranger has been printed and circulated. That gentleman has lately instituted an inquiry, as Inspector under the Health of Towns Act, into the sanitary condition of Southampton, which he has conducted with admirable judgment and laborious investigation. His impartiality, moral weight, and scientific knowledge, have gained the confidence of all parties; and we anticipate that, acting under his advice, we shall avail ourselves to the utmost extent of the advantages which nature has abundantly conferred upon our locality.

John Drew.

Southampton, *Jan. 26th*, 1850.

FARM DRAINING AND WATERING.

We extract the following from a paper on "*Watering of Farm Fields in Periods of Drought, and for the Distribution of Liquid Manure by Pumping, and a System of Pipes*," by Mr. Smith, of Deanston, which lately appeared in the *North British Agriculturist*:—

The farmer, although, no doubt, it must have frequently occurred to him that much benefit would arise from the command of moisture, yet, without possessing the knowledge necessary to enable him to ascertain the practicability of applying water, artificially, over his vast fields, smothers his wish with a sigh, and makes no further inquiry on the subject. It is for those who have the knowledge of the whole subject to make the inquiry; and, from peculiar circumstances, I have been enabled, not only to make the inquiry, theoretically, but to have it put in practice; and I shall now enable you to lay before your readers an outline of this important improvement.

The pumping of water and the conveyance of it in pipes costs a much smaller sum than most people have any idea of; and there is no limit, within fifty miles, to which it could not be transmitted. It has been ascertained, from many practical workings, on various scales, that the mere working of a steam-engine, to pump water where coals are about 10*s.* a ton, will not cost more than 1*s.* for 30,000 gallons, raising it 100 feet high; of course, every additional 100 feet it is raised will cost as much more. The cost of laying down the permanent pipes, necessary for conveying and distributing the water upon the ground, will amount to about two pounds per acre, provided that pottery-ware pipes are used, which kind will be found quite sufficient, where the pressure does not exceed 200 feet of water. In districts where there is high land within a distance of ten miles, the water may be collected and stored in reservoirs and conveyed to the farms by gravitation. Thus, pumping would be rendered unnecessary, and an abundant supply may be had at small cost.

The distribution will be most conveniently made upon each field by using hose or other surface pipes, jetting the water upon the land from convenient points, and it may be thrown in the shape of rain by any common labourer (with a little instruction.) In this way, a labourer with a boy as his assistant may effectually water ten acres in a day, at a cost of about 3*s.* for wages: and, adding 2*s.* for the cost of the fetching and removal of the surface pipes by a horse and cart, with a sum to cover the interest of the outlayed money, chargeable to each application, the whole will amount to 5*s.*, being at the rate of 6*d.* per acre; and, adding 6*d.* per acre for pumping, the full cost will be 1*s.* per acre.

This to a practical farmer will at once appear an insignificant charge for a soaking shower of rain in a dry period; and, if it is in summer weather, when there is heat, the growth of whatever plants are in the ground will be greatly promoted; and, what is very important, the permanent injury, by stoppage of growth for a period, which takes place by excessive and continued drought, will be avoided; so that, when the natural moisture returns, the plants will proceed in their growth in a healthy condition, and the certainty of an early and abundant crop will be the result. In the flat countries, where water cannot be made available from reservoirs in the upper country, the whole water required may be pumped by the steam-engine usually employed for thrashing the grain, and at an extremely small cost; and since it has been elsewhere demonstrated that manure may be most efficiently applied in the liquid form, the watering pipes and apparatus can be used with great advantage in distributing the manure, by which they would perform the double office of supplying abundance of water in dry seasons, and of distributing the manure at all seasons, when proper to apply it.

In the application of liquid manure, much dilution is found to be absolutely necessary: and the farmer should always be provided with an abundant supply of water, wherewith to mix his liquid manure from the farm, or to dissolve and mix with such artificial manures as he may find it profitable to employ; in this way, the most minute shade of nourishing matter may be given at such times as the plants may require. It has been ascertained by the analysis of drainage water, that a considerable portion of the dung put upon land passes off with the superabundant rain water. I, therefore, propose that, upon every farm, there should be a pond or reservoir to catch and store up the drainage water of the wet season, that it may be thrown upon the land in dry periods—thus saving, as far as it is possible, the enriching matter, which would otherwise be lost. This points to the lowest part of the farm as the most proper site for the homestead or farm-buildings, that the steam-engine may be contiguous, at the same time, to the farmstead and to the reservoir. Such position for the farmstead would be most suitable in another important point of view. The system recently called high farming would seem to be imperatively called for in the present condition of the agriculturists of this country, when a greater proportion of rearing and feeding of cattle must be carried out on every farm, so that a larger amount of manure may be produced, with a more profitable application of the food raised. To this end the liquid manure and distribution by pipes will greatly contribute; whilst having the farmstead in a low position will assist in the carting home of the increased green crops for house-feeding, being chiefly down hill, and will be, to a certain extent, advantageous for the carrying home of grain crops as well. The farmstead will generally thus be in a more sheltered position, which in all respects will be advantageous, except with the single exception of drying of grain in the stack, which process can be placed under the more immediate control of the farmer by cheap and efficient artificial means.

All over the Lothians, and the other more advanced districts in Scotland, the steam-engine is a common appendage to every farmstead of any extent, for the purpose of thrashing the grain, cutting the straw and roots, and bruising grain, &c.; and as such engines are employed but a very small portion of time, a forcing pump may be attached for the purpose of pumping water and liquid manure. The application of the common liquid manure of a farm has hitherto been an uphill work, and must always be so when a manure cart is employed as the means of conveyance and distribution; and the farmers who have taken the trouble to ascertain the cost of carrying out their liquid manure by cart must have long ago found that it is very great, and that in most instances (to use a Scotch phrase), "The cost will o'ergang the profit." The application is generally limited to grass lands, where much injury is frequently done, by so much carting as is necessary. When the liquid is applied in dry periods the grass is frequently injured by the strength and acrimony of the fluid: to dilute it with water sufficiently would add very much to the expense of the conveyance and distribution by cart; but when pipes and a steam-engine are employed, a large amount of dilution adds very little to the necessary expense.

The permanent pipes should be placed two, or two and a half feet under the surface, so as to remove them from the influence of severe frost, and from any interference with the deepest working of the land, and it will be sufficient that there be only one or two points of communication with these pipes in each field, as removable pipes, laid upon the surface, are found sufficient to convey the liquid to the points from which the water or liquid manure has to be jetted. These pipes, which are made with slip-joints, can be removed from field to field, so that one, or at most two sets of removable pipes will suffice for a moderate-sized farm. I have thus endeavoured to lay before my readers an outline of my plan for an artificial supply of moisture to the soil.

PARKER'S WATER WHEEL.

This important improvement is now extensively in use in nearly every State in the Union. By the most careful scientific tests, and by observations in many instances in which it has been substituted for overshot and high-breast or pitch-back wheels, it has been fully proved to be more effective in point of economy of water than gravity wheels; while its simplicity, its not being impeded by backwater, or obstructed by ice, its convenience of arrangement for inspection and management, the smallness of the space it occupies, its great durability, its not being liable to get out of order, and its cheapness, especially for great powers, are important advantages not possessed in an equal degree by any other motor.

Fig. 1.

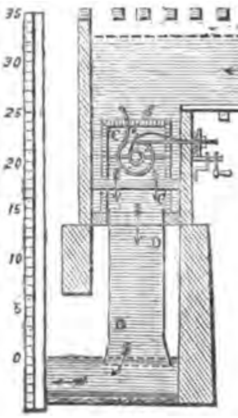
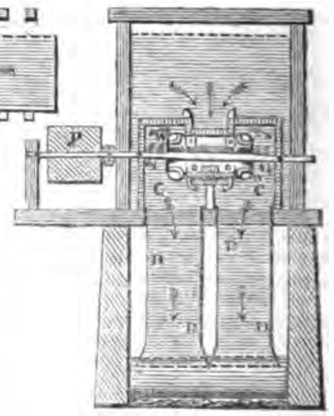


Fig. 2.



The above figures represent one of these wheels recently established in the Agawam Canal Company's Cotton Mill, at West Springfield, Mass.; fig. 1, being an elevation or vertical section through the axis of the wheel; fig. 2, an elevation across the shaft, representing a section of the penstock and draft tubes, and a profile of the helical inlet The parts of the drawing have their true proportions according to the scale.

The fall of water operating the wheel is 31 feet; its full power is estimated at 250-horse power, with an expenditure of 6396 cubic feet of water per minute. The wheel consists of a pair of reaction wheels or rims *w*, of a modified and improved form, arranged on a horizontal shaft, and a double helical sluice *o*, which conducts the water into the wheels with a lively annular motion in the direction in which the wheel moves. The wheel, with its helical sluice, is placed within the penstock, or reservoir supplying it, and is entirely surrounded with water, the extremities of the shaft only protruding from the sides; its axis is 20 feet high from the surface of the tail water. The water passes from the wheels or rims into two air-tight chambers or cases *c*, called "draft boxes," from which it passes into two air-tight iron tubes *d*, called "draft tubes," which terminate and discharge the water beneath the surface of the lower level. The air being entirely excluded from these draft boxes and tubes, and their sections being many times greater than the aggregate openings of the wheel, the water within them descends slowly, being held up by the pressure of the atmosphere on the lower level. It consequently acts by its gravity in giving the water force and velocity, in its passage through the helical inlets and wheel, as effectually as it would if it were over the wheel and acted by its pressure as head water. The wheel is 40 inches in diameter, and, at its proper working speed, makes 220 revolutions per minute. The power is transmitted directly to the line shafts of the mill by belts, from drums or pulleys *p*, on the extremities of the shaft of the wheel. The drums are 6 feet in diameter, and the pulleys on the line shafts 10 feet; the belts consequently travel at the rate of 4148 feet per minute, or a little more than 47 miles per hour, giving the line shafts 132 revolutions per minute. With the gate *t*, (which admits the water to the wheel,) a little more than half drawn, the wheel drives with full speed 7000 throstle spindles, and about half of the additional line shafting necessary for the balance of 16,000 spindles, (the number the mill is to contain when filled), a number of iron and wood lathes, circular saw, &c.

The water required to effect this is about 4500 cubit feet per minute. From a comparison of this resnlt with that of wheels previously erected for propelling cotton mills, working with the gate partly drawn, it is confidently anticipated that the full power of the wheel will drive 13,000 spindles. The company expect to attach machinery sufficient to require the whole power in the course of a few months. The whole cost of the wheel, with all the parts pertaining to it, was about 5000 dollars.

This wheel was substituted for a pitch-back or high-breast wheel, 32 feet in diameter and 17 feet wide, which was operated by the same fall of water. It was made almost entirely of iron, the buckets and soling only being of wood. The quantity of water required to propel it was estimated at 4800 cubic feet per minute. The greatest power that could be got from it was only sufficient for 5000 spindles; another thousand was attached, but it could not be made to drive them with sufficient speed. It was erected early in the present year, and, after running about three months, constantly requiring expensive repairs, it was deemed expedient by the company to remove it, and substitute one of Parker's, which, as yet, appears to the directors and managers of said company to possess many very superior advantages, as compared with the old wheel, there being much less liability to failure. Another important advantage is in getting up the required speed for the machinery without the use of intervening gearing; thus saving a heavy expense in repairs, and a large amount of oil.

Parker's wheels, in the form here represented, are now in operation in the mills of the following proprietors, to whom those interested are referred for a confirmation of that which is here stated.

	Horse power.	Feet fall.
T. F. Plunkitt, Pittsfield, Mas., Cotton Mill	65	14
J. Barker & Brother, Pittsfield, Mass., Casinet Mill	15	11
Plattner & Smith, Lee, Mass., Woollen Mill	45	9
Glendale Woollen Company, Stockbridge, Mass., Woollen Mill	65	14
Berkshire Woollen Company, Great Barrington, Mass.	45	9
White & Sheffield, N. Y. City or Jos. Kingsland, Saugerties, N. Y. } Saugerties Paper Mill.	140	26
Jos. Bailey, Douglasville, Berks Company, Pa., Rolling Mill	65	14
New Brunswick Manufacturing Company, J. Stark, Agent, New Brunswick, N. J., Cotton Mill	38	12
Agawam Canal Company, D. Jakeworth, Agent, West Springfield, Mass., Cotton Mill	250	31

With the exception of the last-mentioned, these wheels have been in operation from one to five years, and so far as has come to the knowledge of the writer, neither of them has required repairing to the amount of a single dollar, nor been out of working order for an hour, since they were first put in operation.—*American Franklin Journal.*

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Jan. 7.—T. Bellamy, Esq., V.P., in the Chair.

Mr. Fergusson read a paper 'On the Architecture of Southern India,' which we give, in full, in another portion of the *Journal*, p. 37.

The following letter, from Mr. Edward Falkener, was then read:—

Dear Sir,—I just have time to write this hasty memorandum of the recent excavations at Rome. On the declaration of the Republic at Rome, the government, actuated by the triple motive of pride in the ancient glory of their ancestors, love of the fine arts, and a desire to provide for the temporary necessities of the indigent part of the population, ordered excavations to be commenced in the Roman Forum. The work was carried on with great energy, notwithstanding the declamations of the anti-Republicans, who inveighed against the barbarism of cutting down the old trees in the Campo Vaccino; but who now with equal ardour praise up the French government for continuing the excavation. Little, however, has at present been discovered, although a large quantity of earth has been turned up. The part excavated has been that adjoining the south-eastern side of the Column of Phocas. The only remains brought to light are some unimportant brick walls of the late Empire, and a stone pavement apparently of the Forum, with one continued step at the side, which probably marks the line of portico, although no columns were found to justify this supposition. The works, however, still continue, and very sanguine expectations are held by the *archæologues* of Rome relative to the result. Other excavations have been conducted in the Forum of Trajan, but with no better success, for with the exception of some fragments of sculpture, no remains of interest have been discovered.

More important fruits have been obtained in the Trastevere. In pulling down and rebuilding an old house, a very fine statue of Greek art was found, representing an athlete, who, after issuing from the thermæ, is represented cleaning his left arm from the perspiration of the bath with a strigil. It is of white marble, and rather more than the size of life. Again, in another part of the Trastevere, while removing the paving stones and earth from the carriage-way, I believe for one of the barricades, a large bronze horse was discovered, which is esteemed of early art from the short neck and other peculiarities displayed in it. The near fore leg has unfortunately been crushed and shattered, but no part of it is wanting, and it is considered that it can easily be restored. The seat is wanting, and from that circumstance it is difficult to say whether an equestrian figure was attached to it. This work of art has been placed in the Capitoline Museum, and the athlete in the Vatican. Lastly, in pulling down an old house in the Via Graziosa, near Sa. Maria Maggiore, some highly interesting remains were discovered of an ancient Roman house, consisting of several fresco paintings on a brick wall. From the circumscribed nature of the ground, there being other houses on each side, further excavation was impossible; but every precaution has been taken for the preservation of what has yet been discovered. The paintings represent the adventures of Ulysses, a circumstance which is highly interesting, from the fact that this is one of the subjects recommended to us by Vitruvius, for the decoration of private edifices. The paintings are moreover remarkable from having the name of the figures scratched with a point over the head of each figure. At the present moment eight of these paintings have been exposed. Immediately above these frescoes, on the *first floor*, are three semicircular-headed windows, the lower *voussoirs* on each side were found in their place, though the crown of the arches had fallen in or been removed. They have since been restored. Again, on the *second floor*, on a cross wall lying at right angles with the other wall, and forming the party wall of the adjoining house, the base of a marble column of the Corinthian or Composite order, and of good style, was found *in situ*, which, whether we regard the dimensions, about 20 inches diameter, or the height at which it was found, renders it of the highest interest as connected with the study of the domestic architecture of the ancients. It is extraordinary that these remains should have existed above ground for so many ages. Apologising for this hurried description,

I am, &c.,

Thos. L. Donaldson, Esq., Prof., &c. Edward Falkener.

INSTITUTION OF CIVIL ENGINEERS.

Jan. 8.—William Cubitt, Esq., President, in the Chair.

This evening was devoted to the reading of the address from the President, on taking the Chair for the first time after his election, and which is given at length in another portion of the *Journal*, p. 41.

Jan. 15.—The paper read, was "*An Account of the Blackfriars Landing Pier.*" By Mr. F. Lawrence.

This pier commences on the Middlesex side of the river, to the east of Blackfriars Bridge, at Chatham-place, and continues parallel to the bridge, and at a distance of forty feet from it, for a length of one hundred and eighty-five feet. The body of the pier (exclusive of the head) is supported on four piers, two of which consist of a single row, and two of a double row of piling, forming three spans of fifty feet each, and having about eight feet headway under them at high water. The floating barge, or dumby, on which the passengers land, is one hundred feet long and twenty-five feet wide, rising and falling with the tide, in grooves at each end, formed by piles and protected by dolphins. The connection between the dumby and the pier is by a moveable stage eight feet wide and fifty feet long, secured to the pier head, at one end by a hinge joint, and the other end similarly connected to a flight of steps on wheels, which moves on a tramway fixed to the deck of the barge. The principal portion of the timber used in its construction was fir; but the whole, whether of fir or oak, was impregnated by Payne's process—those portions below high-water mark being further protected by a coating of Stockholm tar. The whole of the cast and wrought iron work was galvanised.

The Corporation of London had observed the necessity for an improved landing place, so early as 1841, but it was not until a fatal accident occurred in 1844, that any decided steps were taken in the matter: then Messrs. Walker and Burges received instructions to prepare a design, which was approved, and the pier was commenced in March 1845, and completed in October of the same year, under the superintendence of Mr. Hewett, M. Inst. C.E. The total cost was about 4,000*l.*

The next paper read was a "*Description of a Timber Bridge, erected over the River Ouse, on the line of the Lynn and Ely Railway.*" By Mr. J. S. Valentine, M. Inst. C.E.

The total length of this bridge was four hundred and fifty feet, divided into eleven bays, ten of thirty feet span each, and one over the river of one hundred and twenty feet span on the square, and one hundred and twenty-one feet six inches on the skew. This river-opening consisted of three laminated timber bows, resting upon stone piers, the material for which was procured from the New Leeds Quarries. The dimensions of the bows were, length of chord, one hundred and twenty-one feet six inches; versed vine, fourteen feet two inches; and their depth, three feet eight inches; the width of the outer bows was two feet two inches, that of the centre bow two feet nine inches. They were formed of fifteen layers of three inch deals, abutting upon a cast-iron plate, bolted to the tie-beams, which consisted of two whole timbers scarfed and bolted together. Each tie-beam was suspended from the bows by thirteen wrought-iron rods, two inches in diameter, and between these diagonal struts were fitted. Transverse joists, notched on to the tie-beams, extended across the whole width of the bridge, and on these the rail bearers were laid, the intervening spaces being filled with three inch deals, laid longitudinally.

The works were commenced in the autumn of 1846, and completed in October 1847; the total cost of the superstructure being about 3,744*l.* When tested, by placing three locomotive engines on each line of rails, the total deflection was only three-eighths of an inch.

Jan. 22.—The paper read was "*On the Periodical Alternations and Progressive Permanent Depression of the Chalk Water Level under London.*" By the Rev. J. C. Clutterbuck.

The author began by defining the Chalk Water level to be, "the height to which the water rises at any point or continuous series of points *in* the chalk, or *from* the chalk in perforations, through the London and plastic clays, above the chalk." The term 'Artesioid' was used to describe those wells sunk through the London and plastic clays, in which the water rose from the chalk, or the sands of the plastic clay formation, above the level of those strata, though it might not rise to, or overflow the surface of the ground.

Reference was made to papers read before the Institution in 1842 and 1843, in which it was shown that the chalk water level was described by an inclined line drawn from the highest level at which the water accumulated in the chalk, to the lowest proximate vent, or outfall: a general rule, which was found to hold good, not only where the water was found by sinking into a permeable stratum, but where, as in the London Basin, the water rose from a permeable stratum, through perforations in any impermeable stratum above it.

The example treated of in the paper, was described by a line inclining at an average of about 13 feet in a mile, from the outcrop of the London and plastic clays, to mean tide level in the Thames, below London Bridge.

The height to which water rose in the Paris Basin, from the lower green sand, was adduced in confirmation of that rule. Before the artesian well at Grenelle was bored, M. Arago calculated, that the water would rise above the level of the soil at Paris, as it rose above that level at Elbeuf, near Rouen. The height at which the water was found in the lower green sand, near Troyes, being 100 metres above Paris, and 131 metres above the sea, the author found that a line drawn from that point, to the level of the sea at Havre (where the green sand cropped out), passed over Paris and Elbeuf at the elevation to which the water actually rose in both places. A calculation based on the same principle (taking the level of the water in the lower green sand, at Leighton Buzzard, at 280 feet above the sea), showed that if the chalk and gault were bored through in London, the water from the green sand would rise 150 feet above Trinity high-water mark.

Passing from the natural to the actual condition of the chalk water level, under London, there was a general permanent depression of from 50 to 60 feet below Trinity high-water mark. Measurements of a well in London, in which the level was seldom disturbed, showed periodical alternations, coincident with the exhaustion and replenishment of the chalk stratum by natural causes, to the amount of 4 ft. 6 in., and a permanent depression of 1 ft. 6 in. per annum, or 12 feet in eight years.

Again, referring to former calculations, it was shown that the margin of this depression was extending in a greater ratio towards the North than to the South, or S.E. Since 1843, the level was permanently depressed at Hampstead-road, 10 feet; Camden Town, 19 feet; Kilburn, 20 feet; and Cricklewood, 10 feet. The limit of the depression being, in 1843, between the latter places.

Allusion was then made to the influx of water at the point where the Thames passed over the outcrop of the sands of the plastic clay formation, and the chalk, as a point to be determined by geological inquiry, and connected with observations as to the action of the tides on the level, and the chemical quality of the water, in that neighbourhood.

The general conclusion drawn from all these facts was, that the rapidity of exhaustion from Artesian wells under London, greatly exceeded the rapidity of supply; that the amount of defalcation was marked, and could be measured by the extension of a progressive permanent depression, proving that the supply of water from the chalk stratum became each year more precarious, and less to be depended upon, even should there be no addition to the Artesioid wells in and around the metropolis.

In the discussion which ensued, it was shown that only such a supply of water percolated annually through the chalk stratum, as could be accounted for by the discharge from the rivers of the upper district. The results yielded by Dalton's Rain Gauge, as used by Mr. John Dickinson, were adduced in proof of this position.

The chemical analysis of water from wells sunk into the chalk, showed the probability of an influx of the tidal water of the Thames, to replenish the vacuum caused by the immense extent of pumping from the London wells.

On the other hand it was contended, that from the great extent of surface whence the chalk derived its supply, there might be such a surplus store of water, as would warrant any amount of pumping, for the domestic supply for the metropolis.

ROYAL SCOTTISH SOCIETY OF ARTS

Dec. 10, 1849.—Thomas Grainger, Esq., C.E., President, in the Chair.

The following communications were made:—

1. The President delivered an address on the desirableness of obtaining communications relative to the Construction and Details of Engineering and other Public Works, accompanied by the necessary Models and Drawings.

2. "*Notice of a Chromatic Stereoscope.*" By Sir David Brewster, K.H., F.R.S., V.P.R.S.E.

The instrument consists of one lens 2½ inches in diameter or upwards, through the margin of which each eye looks at an object having *two* colours of different refrangibility. The effect of this is to cause the two parts of the object thus differently coloured, to appear at different distances from the eye, just as in the *Lenticular Stereoscope,* the two parts of an object that are nearest to one another in the double picture rise in relief, and give the vision of distance as of a solid figure. The instrument may consist of two semilenses, convex or concave, or of two prisms with their refracting angles placed either towards or from one another; and the effect is greatly increased if the lenses or prisms have high dispensive powers, such as flint glass or oil of cassia.

NOTES OF THE MONTH.

RAILWAYS OPENED IN THE YEAR 1849.

The aggregate length of English railways opened for traffic in the year 1849 was 750 miles; of Scotch railways 73½ miles, and of Irish railways 114 miles—making the aggregate length of railways opened in the United Kingdom during the past year 937 miles, being 270 miles less in extent than those opened during the year 1848.

The English lines were—

Chester and Holyhead, Mold branch, 13¼ miles.
East Anglian, 24 miles.
East Lancashire, 45 miles.
Eastern Counties and Norfolk, 15 miles.
Eastern Union, including the Stour Valley line, 43 miles.
Furness, 17½ miles.
Great Northern, 33 miles.
Great Western extensions, 30 miles.
Lancashire and Yorkshire branches, 12 miles.
Leeds and Thirsk, 30 miles.
London and Blackwall, 1⅜ mile.
London and North-Western (Huddersfield and Manchester, and Leeds and Dewsbury), 44 miles.
London and South-Western branches, 22¾ miles.
Manchester, Buxton, Matlock, and Midland, 12 miles.

Manchester, Sheffield, and Lincolnshire branches and extensions 97 miles.
Midland extension, 16 miles.
Newcastle and Carlisle branch, 4 miles.
North Staffordshire, 51¼ miles.
North-Western, 37 miles.
Reading, Guildford, and Reigate, 45 miles.
Shrewsbury and Birmingham, 30 miles.
Shropshire Union, 30 miles.
South Devon, 2¼ miles.
South-Eastern (North Kent), 25¾ miles.
South Staffordshire, 17¾ miles.
South Yorkshire, 9 miles.
Whitehaven and Furness, 16¼ miles.
York, Newcastle, and Berwick branch, 21¼ miles.

The Scotch lines were—
Aberdeen, 32 miles.
Caledonian extensions, 18 miles.
North British branches, 23¼ miles.

The Irish lines were—
Cork and Bandon, 9¾ miles.
Dublin and Belfast Junction, 22 miles.
Dundalk and Enniskillen, 18 miles.
Great Southern and Western extension to Cork, 58¼ miles.
Newry, Warrenpoint, and Rostrevor, 6 miles.

RAILWAY TRAFFIC, 1849.

The gross traffic receipts of railways in the United Kingdom for the year 1849 is estimated at 11,013,820*l.* on 5,161 miles of railway, being an increase of 954,820*l.* in the receipts over those of the preceding year on 4,326 miles, and also an increase of 835 miles of railway in operation.

Independent of these railways, there are about twenty new lines in operation, of an aggregate length of 445 miles, the traffic returns on which are not published weekly, but may be estimated at 200,000*l.* for the past year. In addition to these, there are fifteen other lines, of an aggregate length of 344 miles, belonging to old railway companies, who do not publish their traffic returns; but it appears from the returns to the Railway Commissioners that the gross receipts on these lines are about 470,000*l.* per annum. These sums, added to the above, show that the gross traffic receipts on all the railways in the United Kingdom during the past year amounted to 11,683,800*l.*; and the aggregate length of railway open and over which the traffic was carried was 5,950 miles, being at the rate of 1,963*l.* per mile per annum.

With regard to the traffic returns of the railways in Great Britain and Ireland, published weekly, they show a progressive increase during the past eight years as follows:—

	£		£
1842	4,341,788	1846	7,689,870
1843	4,842,650	1847	8,975,671
1844	5,610,980	1848	10,059,000
1845	6,669,230	1849	11,013,820

The annual increase in the receipts has been very considerable, partly arising from the continual development of the traffic on the trunk lines, and partly from the additional receipts derived from the opening of new lines and branches. The increase of traffic in the year 1843 over that of the preceding year amounted to 500,870*l.*; in the year 1844, to 768,337*l.*; in 1845, to 1,058,340*l.*; in 1846, to 1,020,650*l.*; in 1847, to 1,285,780*l.*; in 1848, to 1,083,335*l.*; and in 1849, the increase over the preceding year amounted to 954,810*l.*

At the end of the year 1842, 1,510 miles were open to the public; during the next year an additional length of 56 miles of new railway was opened for traffic; in 1844 a further length of 194 miles was opened; in 1845, 263 miles; in 1846, 593 miles; in 1847, 839 miles; in 1848, 975 miles; and in 1849, a further length of 834 miles, making at the end of the year a total length of 5,161 miles in operation.

The average traffic receipts per mile show the effect of opening within the past three years so many miles of branch and competing lines of railway. During the year 1842, the gross traffic receipts averaged 3,113*l.* per mile; in 1843, 3,085*l.*; in 1844, 3,278*l.*; in 1845, 3,469*l.*; in 1846, 3,305*l.*; in 1847, 2,870*l.*; in 1848, 2,556*l.*; and in 1849, 2,302*l.* per mile. This shows a gradual falling off in the average traffic per mile during three years of more than 30 per cent., and there seems every probability of its continuance, so long as the present erroneous system is pursued in constructing unproductive extensions and unnecessary branches. The reduction in the receipts per mile would be a matter of no great consequence, provided the average cost of constructing the railways was proportionably reduced, say in the same ratio of the traffic per mile, from 33,000*l.* to 23,000*l.* per mile, and so on in like manner with every additional mile added to the system. Unfortunately this is not the case, as the following will show:—In 1842 the cost of the railways in operation averaged 34,690*l.* per mile; in 1843, 36,360*l.*; in 1844, 35,670*l.*; in 1845, 35,070*l.*; in 1846, 31,860*l.*; in 1847, 31,700*l.*; in 1848, 34,234*l.*, and in 1849, 35,214*l.* On a comparison of the average cost [illegible] mile in 1845 of 35,070*l.*, when there were only 2,040 miles of railway open, with the average cost in 1849, of 35,214*l.*, when there were 5,160 miles open, it shows that an increase in the cost per mile has taken place, notwithstanding that 3,120 miles of additional railways and branch railways have been constructed.

The increase instead of a decrease in the average cost per mile is a most alarming feature in railway statistics, because it shows clearly that the continual additions to the capital accounts of the old and completed lines of railway far outweigh all the professed advantages of constructing thousands of miles of new railways and branches at considerably less cost than the average expenditure per mile on the old trunk lines. It was stated both in and out of Parliament that the new lines authorised in the 1844 and succeeding sessions would not exceed 25,000*l.* per mile, and that a considerable portion of them would not cost above 18,000*l.* per mile. Some have been constructed within the estimate, and others have exceeded it. The serious evils arising from the improper practice of adding large sums every half-year to the capital accounts of old railways must be remedied in future by closing at once their capital accounts, and also the capital accounts of every new railway, before the end of two years after the opening of the line; otherwise there can be no foundation for confidence in either railway property or railway management.

The capital expended on railways, the traffic returns of which are published every week, amounted in July 1842, to 52,380,000*l.*; in 1843, to 57,635,000*l.*; in 1844, to 63,489,000*l.*; in 1845, to 71,648,000*l.*; in 1846, to 83,165,000*l.*; in 1847, to 109,528,000*l.*; in 1848, to 148,200,000*l.*; and in July 1849, to 181,000,000*l.* The gross traffic returns per cent. on the capital expended amounted, in 1842, to 8·29 per cent.; in 1843, to 8·42; in 1844, to 8·84; in 1845, to 9·30; in 1846, to 9·25; in 1847, to 8·20; in 1848, to 6·78; and in 1849, to 6·13 per cent. This gradual decrease in the revenue, with a greatly increased capital and mileage, shows the absolute necessity of closing the capital accounts.

The expenditure on the new and old lines, the traffic returns of which are not published weekly, amounts to about 16,000,000*l.*, that is, 9,000,000*l.* on the former, and 7,000,000*l.* on the latter, making, with the 181,000,000*l.*, a total of 197,000,000*l.* expended on 5,950 miles of railway, being an average cost of 33,110*l.* per mile.

PROTECTION OF IRON FROM OXIDATION.

At the Exposition at Paris in 1849, there were exhibited numerous articles manufactured in iron, covered with a kind of transparent vitreous coating, completely spread over the surface of the metal, like a varnish, and capable of affording a perfect protection against the action of the air, or any other oxidizing agent. This appears to be an invention susceptible of many useful applications; for, whether the iron be in the state of a rolled plate or bar, or drawn into tubes; whether it be cast into water pipes or into articles of the most elaborate form and design, as vases, and other ornamental works, it can be equally well endowed with this protective coating—it is also a matter of indifference whether the article be made of forge or cast-iron. The following is stated to be the process employed in imparting to the iron the vitreous surface:—Firstly, the object, whatever its shape may be, is thoroughly cleansed by dilute acid, which serves to remove, from the metallic surface, grease, dirt, and every trace of oxide; this is important, for, if any foreign matter remain upon the surface, the perfect adherence of the fused glass will be effectually prevented, when that part of the operation is reached. After the action of the dilute acid, the work is to be well washed and then dried; when perfectly dry, it must be brushed over with a tolerably strong solution of gum-arabic, which may be applied by means of a camel-hair brush. Over the whole extent of the gummed surface, powdered glass, of a peculiar kind, is then sifted, and care must be taken to cover every part of the surface with this powder, otherwise the vitreous coating will be imperfect when the operations are completed. When thus prepared, the work is introduced into a furnace or retort, heated to 100° or 150° centigrade; (212° to 302° F.) and, when thoroughly dry, it is removed to another furnace, where it is brought to a cherry-red heat; the vitreous matter, which adhered to the gummed surface of the metal, now undergoes fusion—the progress of this stage of the process is ascertained by looking through a small opening (contrived for this purpose) into the heated chamber. When the fusion is complete, and the glass seems to have flowed over the whole of the surface, the article is removed from the furnace and placed in a close chamber, from which the air is entirely excluded—here it is kept until it has cooled down to the temperature of the atmosphere. The vitreous compound, applied to the surface of the metal, consist of the following substances:—Powdered flint glass, 130 parts; carbonate of soda, 20½ parts; boracic acid, 12 parts. These must be melted together in a "glass pot," and a fusible glass will be the result; when cold, this must be pounded with care, so that it may be reduced to a powder, sufficiently fine to pass through a silk sieve. When thus prepared, it is ready to be applied to the surface of the iron, according to the method described above. If, after the first process, the coating of vitrified matter on the metal should prove not to be quite perfect, the manipulation must be repeated, a second coat of powdered glass being applied in the same manner as the first. It is necessary that the vitreous matter which forms the coating should be quite free from foreign matter, for if the object to be coated be oxidized or greasy, the coating of glass will not adhere, and the result of the operation will be, consequently, very imperfect.

Tracing Paper.—Messrs. Waterlow and Sons have recently introduced a very useful description of French tracing paper for the engineer's office. It is to be had 40 inches wide and 21½ yards in length, and is remarkably transparent.

Assyrian Antiquities.—Major H. Rawlinson, the E.I.C.'s Political Agent in Turkish-Arabia, and H.M.'s Consul at Bagdad, who has lately arrived in this country from Bagdad, has brought with him a quantity of casts of Babylonian inscriptions, and also some packages containing figures of stone and terracotta, being remains of Assyrian antiquities; and they are intended to be deposited in the British Museum and other scientific institutions of the metropolis. Lord Mahon exhibited some of the casts at the Society of Antiquaries on the 24th ult.

Testimonial to Mr. Dockray, Resident Engineer on the North-Western Railway.—As a testimonial of respect for his well-known and uniform integrity of character, Mr. Dockray has had the proud gratification of being presented by his brother officers in the London and North-Western Railway, and by other gentlemen professionally connected with him, with a half-length portrait of himself, painted by Phillips, accompanied by a purse of 60 sovereigns, and 500*l.* of London and North-Western Stock at par. Mr. Dockray was, moreover, presented at the same time with an elegant silver service of plate, of the value of 198*l.* Both portrait and service bear the following inscription:—"This service of plate, together with this portrait, and 500*l.* London and North-Western Railway stock, was presented to Robert Benson Dockray, Esq., M.I.C.E., resident engineer of the London and North-Western Railway, by 700 subscribers, consisting of his brother officers, and private friends, as a testimonial of their respect and esteem, November, 1849." The portrait has been engraved in a most masterly style by T. L. Atkinson, Esq.

East India Railways.—Mr. J. C. Melvill, the secretary of the East India Company, has been appointed the *ex officio* director of the India Railway Companies, in pursuance of the Acts and the respective contracts with these bodies, and three engineers have been chosen by the East India Peninsular Company to go out to Bombay, for the purpose of proceeding at once with these works. The gentlemen selected are Mr. J. Berkeley, formerly a pupil of Mr. R. Stephenson, and subsequently a sub-engineer on the North Staffordshire line; Mr. C. Ker, resident engineer, under Mr. Locke, on the Aberdeen line; and Mr. Graham, a nephew of Sir James Graham, and a pupil of Mr. Stephenson.

Monster Pontoon at New Holland.—Another great step has been taken to bridge across the Humber. A floating island, half an acre in extent, has been launched into the sea. This island is formed wholly of iron plates, in the form of a rectangular pontoon; and floats at the end of the pier of the Manchester, Sheffield, and Lincolnshire Railway station, opposite Hull. The pontoon is connected with the pier by means of two tubular platforms or bridges, which always afford an easy descent, and the passengers alight from the carriages and walk under cover to the boats, which convey them in ten minutes, at the rate of fifteen miles an hour, across the ferry. This pontoon is part of the great system of railway ferries designed by Mr. Fowler for the Hull station, the successful and complete carrying out of which is a principal condition of the success of the railway, which it connects with its most populous eastern terminus. The great mass was launched on the 4th ult., with perfect success—and on going into the water floated at the exact line marked out for it, thus proving the accuracy of the previous calculations of the engineer. It was constructed by Messrs. Wilson and Co., of Leeds, as contractors, under the immediate superintendence of Mr. Ikin, and it is an excellent piece of workmanship, as well as a most successful engineering design.

New Peninsular Steam-Fleet.—We understand that, in anticipation of securing the contract for conveying the mails between India and Australia, and of performing the whole of the Mediterranean and Bombay service, the Peninsular and Oriental Company have determined on building seven new and powerful paddle-wheel steam vessels. Todd and Macgregor, of Scotland, are to build two of the number, they having succeeded so well with the Sultan, the ship last built. The vessels are to be built of iron.

Navigation of the Ganges.—An iron steam vessel is now being built by Mr. J. Laird, of Birkenhead, intended for the navigation of the Ganges. She is 200 feet long, and 30 feet beam, and will only draw, when loaded, about two feet of water. The form is that of the canoe, shovel-shaped at both extremities, and the bottom, amidships, without keel, forming an inverted gentle segment of an arch; the centre portion, however, or floor, being nearly flat. The rudder is applied at either end, as necessity requires. The vessel is divided longitudinally, into three parts, by tight bulkheads; and traversing these, there are other bulkheads, dividing the whole vessel into 30 water-tight compartments, and adding greatly to her strength. The vessel, which is for the East India Company, will, when finished, be taken to pieces, and sent in a ship to India, to be finally put together.

Mineral Veins.—MM. Malaguti, Durocher, and Sarzeaud, announce that they have detected in the waters of the ocean the presence of copper, lead, and silver. The water examined appears to have been taken some leagues off the coast of St. Malo, and the fucoidal plants of that district are also found to contain silver. The F. serratus and the F. ceramoides yielded ashes containing 1-100000th; while the water of the sea contained but very little more than 1-100000000th. They state also that they find silver in sea salt, in ordinary muriatic acid, and in the soda of commerce; and that they have examined the rock salt of Lorraine, in which also they discover this metal. Beyond this, pursuing their researches on terrestrial plants, they have obtained such indications as leave no doubt of the existence of silver in vegetable tissues. Lead is said to be always found in the ashes of marine plants, usually about an 18-1000000th part, and invariably a trace of copper. Should these results be confirmed by further examination, we shall have advanced considerably towards a knowledge of the phenomena of the formation of mineral veins.

Improved Drilling Machine.—Mr. M. P. Coon, of Lansuyburgh, New York, has taken out a patent for a new stone drilling machine, by which the drill can be worked not only perpendicularly, but horizontally, and at any angle within the plane of a semicircle. This arrangement is effected by the employment of spiral springs, so arranged that they are negative—that is, they are of sufficient power of contraction and extension to counteract, or counterbalance, more than the entire gravitating power of all the machinery required to raise the drill shaft. Upon the same principle, a concussive power is obtained and counteracted; and, consequently, the drill shaft may be worked with any amount of concussive power, and at any angle required. They are constructed of any required size. The drill shafts, weighing from 10 to 1000 lb., will drill any size hole, from ½ in. to 2 ft. diameter; and the concussion, or blow, for cutting the rock, is wholly regulated by the weight of the drill and the height from which it falls. A Mr. Jack, of Maine, has also taken out a patent for working a drill by springs; but which is the original idea, or whether they are identical or otherwise, we have no means of ascertaining.

Burning Water instead of Lamp Oil.—The *New York Sun* has a letter from Worcester, Massachusetts, in which the writer claims to have invented and put in use an apparatus which separates the oxygen of which water is composed, and produces gases for lights. This it does at no other expense than that of the machinery, as no material but that of water is used. The water is decomposed by a current of electricity, evolved by the apparatus. The labour of five minutes, once in two hours in the day, in winding up the machine, is all that is required to produce 250 cubic feet of gas. The expense of the machine is 300 dollars, and it can be carried by a man under his arm. Such is the description of it—time will determine whether it is even so.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM DECEMBER 21, 1849, TO JANUARY 24, 1850.

Six Months allowed for Enrolment, unless otherwise expressed.

Louis Cesaires Charpillion, of Rue de Luxembourg, France, for improvements in locks for guns, and pistols.—December 29.

John Read, of Park-terrace, King's-road, Chelsea, for improvements in machinery fo extracting fluids from animal, vegetable, and mineral substances, and in compressing the same.—December 29.

William Palmer, of Sutton-street, Clerkenwell, Middlesex, manufacturer, for improvements in the manufacture of candles, lamps, and wicks.—December 29.

William Barlow, of Blackheath, civil engineer, and William Henry Barlow, of Derby, civil engineer, for improvements in the permanent ways of railways.—January 3.

Albert Crackell Waterlow, of London-wall, lithographer, for obtaining copies of writings, drawings, and other designs. (A communication.)—January 3.

Alexander Brodie Cochrane, jun., and Archibald Slate, of Dudley, Worcester, engineer, for improvements in the manufacture of iron pipes or tubes.—January 3.

Thomas Lightfoot, of Broad Oak, within Accrington, Lancaster, chemist, for improvements in printing and dyeing fabrics of cotton and of other fibrous materials.—January 3.

William Buckwell, of the Artificial Granite Works, Battersea, civil engineer, for improvements in compressing or solidifying fuel.—January 3. To extend to the Colonies only.

Joe Sidebottom, of Pendlebury, Lancaster, manager, for certain improvements in steam engines.—January 3.

Henry Dorning, of Hearsley, near Bolton, Lancaster, brick and tile manufacturer, for certain improvements in machinery or apparatus for manufacturing bricks, tiles and other similar articles from clay or other plastic materials.—January 3.

David Blair White, of Newcastle-upon-Tyne, doctor of medicine, for an improved mode of ballasting and stowing cargo in ships and other vessels.—January 8.

Matthew Urlwin Sears, of Burton-crescent, St. Pancras, Middlesex, commission agent, for the improved construction of guns, and cannons, and manufacture of cartridges for the loading or charging thereof.—January 11.

Samuel Newington, of Knole, Frant, Sussex, doctor of medicine, for improvements i sowing, manuring; and cultivating land, and of certain of the implements used therein.—January 11.

Bennett Alfred Burton, of the firm of Bennett, Burton, and Burton, of John's-place, Holland-street, Southwark, engineer, for certain improvements in apparatus connected with sewers, drains, and cesspools, also in suction and delivery pipes, and in connecting such pipes or hose; the apparatus connected with sewers, drains, and cesspools being applicable to other like purposes.—January 11.

John Fayrer, of Surrey-street, Strand, commander in Her Majessy's Navy, for improvements in steering apparatus.—January 11.

Alfred Cooper, of Romsey, Hants, grocer, for improvements in steam and other power engines, and in the application thereof to motive purposes; also in the methods of, and machinery for, arresting or checking the progress of locomotive engines and other carriages.—January 11.

James Macdonald, of Chester, coachmaker, for certain improvements in the method of applying oil or grease to wheels and axles, and to machinery; and in connecting the springs of wheel carriages with the axles or axle-boxes.—January 11.

John Glasgow, of Manchester, engineer, for certain improvements in machinery or apparatus for shearing, shaping, punching, and compressing metals.—January 12.

John Milwain, of Manchester, joiner, for certain improvements applicable to the closing of doors, windows, and shutters.—January 12.

Andrew Barclay, of Kilmarnock, North Britain, engineer, for improvements in smelting of iron and other ores, and in the manufacture or working of iron and other metals, and in certain rotary engines and fans, machinery, or apparatus connected therewith.—January 15.

Richard Smith, of Clitheroe, Lancaster, manufacturer, for certain improvements in looms for weaving.—January 17.

Henry Cowing, of Stamford-street, Blackfriars, gentleman, for improvemenes in obtaining motive power, and in steam and other ploughs, in land carriages, in fire-engines, in raising water for draining and other agricultural purposes, and in apparatus for evaporating saccharine and other liquors.—January 17.

Joseph Nye, of Mill-pond Wharf, Park-road, Old Kent-road, engineer, for improvements in hydraulic machinery; parts of which machinery are applicable to steam-engines and machinery for driving piles.—January 17.

William George Henry Taunton, of Liverpool, civil engineer, for certain improvements in obtaining motive power, and in a means to ascertain the strength of chains and ships' cables.—January 17.

Robert Barbor, of Chatham-place, Lock's-fields, Surrey, metal melter, for certain improvements in artificial fuel, and in machinery used for manufacturing the same.—January 17.

Macgregor Laird, of Birkenhead, gentleman, for improvements in the construction of metallic ships or vessels, and in materials for coating the bottoms of iron ships or vessels, and in steering ships or vessels.—January 19.

William Beadon, jun., of Taunton, Somerset, gentleman, for improvements in conveying away or decomposing smoke and products of combustion from stoves or grates, and in ventilating rooms of residences.—January 19.

George Simpson, of Buchanan-street, Glasgow, civil and mining engineer, for a certain improvement or improvements in the machinery, apparatus, or means of raising, lowering, supporting, moving, or transporting heavy bodies.—January 19.

William Wood, of Over Darwen, Lancashire, carpet manufacturer, for improvements in the manufacture of carpets, and other fabrics.—January 23.

Christopher Nickels, of York-road, Lambeth, Surrey, gentleman, for improvements in the manufacture of woollen and other fabrics.—January 23.

Walter Westrup, of Wapping, Middlesex, miller and biscuit baker, for improvements in cleaning and grinding corn or grain, and in dressing meal or flour.—January 24.

Auguste Reinhard, of Leicester-street, Leicester-square, Middlesex, chemist, for improvements in preparing oils for lubricating purposes, and in apparatus for filtering oil and other liquids.—January 24.

Joseph Long and James Long, of Little Tower-street, London, mathematical instrument makers, and Richard Pattenden, of Nelson-square, Surrey, engineer, for an improvement in instruments and machinery for steering ships, which is also applicable to vices, and other instruments and machinery for obtaining power.—Januar 2

LECTURES ON ARCHITECTURE,

By Samuel Clegg, Jun., Esq.;

Delivered at the College for General Practical Science, Putney, Surrey.

(PRESIDENT, HIS GRACE THE DUKE OF BUCCLEUGH, K.G.)

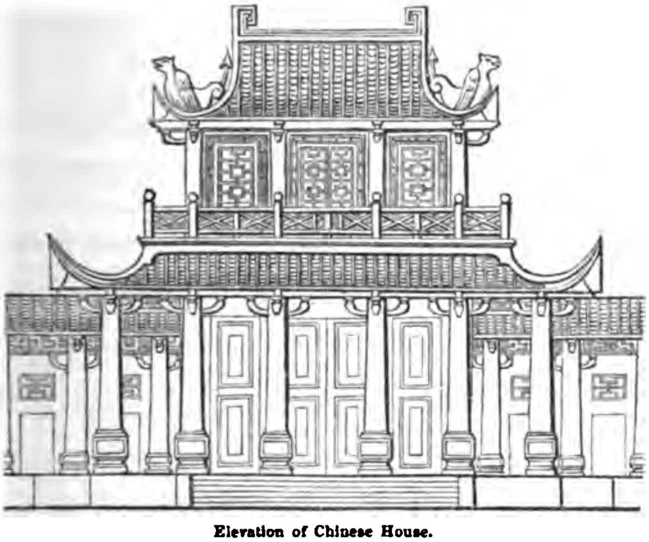
Lecture III.

China.—Central America.—Celtic remains.

We have hitherto been following the traces of the Agriculturist: in approaching China, we come upon the footsteps of the Pastoral tribes, the dwellers in tents,—amongst whom any great progress in the science of Architecture may be looked for in vain.

As it will not be necessary again to refer to China in the course of these Lectures, I must be allowed, instead of confining myself to an historical period, to speak of the architecture of this singular country as it exists at the present day; thus substituting distance of place for distance of time.

In China, the adherence to the original type of the tent is everywhere apparent: their pagodas and towers resemble a number of tents placed one over another, instead of side by side; the houses of the mandarins chiefly differ from those of the lower orders by covering a greater extent of ground; and the palace of Pekin is merely like a camp within an outer encampment, formed by the tent-like houses of the city. Owing to the frailness of material and peculiarly slight style of building, it is not likely that the Chinese edifices could long resist the devastating march of time; indeed, it is supposed that with the exception of the Great Wall, and perhaps a few pagodas, no building exists in that country more than 300 years old. Any description of the ancient architecture of China would, consequently, be merely conjectural. But from the religious and political thraldom to which the Chinese are subjected, from their natural repugnance to change, and from the simplicity of their present style of building, there is no reason to suppose that it differs in any material respect from that of 3000 years ago.



Elevation of Chinese House.

Timber, crude and burnt brick are the materials most in use; the bamboo, which in China grows to a remarkable height and size, is also employed. Stone and marble are rare, and are only partially used even in the public buildings and tombs. The characteristics of Chinese architecture are extreme lightness and gaiety of effect, the tent-like form, the coloured and varnished roofs, and variously-tinted walls—giving, as Sir William Chambers observes, "a pretty and toy-like appearance" to their buildings. The height and size of each dwelling-house must be in exact accordance with the caste of the proprietor; and even the details are regulated by law. A mandarin, who had ventured to erect a mansion of superior elegance, was summoned before the emperor to answer for his presumption; and thought it wise to raze the obnoxious structure to the ground, in order to avert fine or other punishment.

The roofs of the Chinese buildings are convex in their sides, spine, and ribs, presenting the appearance of a pliant material; they are supported by wooden columns without capitals, having, instead, ornamental consoles projecting from the sides, which give additional support to the verandah. The roofs turn up at the eaves, and are finished with a spike, like the hook or fastening of a tent; and this part is frequently decorated with the figure of a dragon, which is the national emblem. The wooden columns being the main support of the roof, the side walls are very slight. The window frames are filled-in with open rectangular patterns, intersecting each other; the railwork of the balconies and verandahs is formed in a similar manner. The interior walls are gaily ornamented with variegated matting, and painted paper or silk. Sometimes, in the upper stories, the partition walls are partly formed of cane trellis-work covered with painted gauze, admitting light and air. The aperture leading from one room to another, or from the corridor to the garden, is frequently a lunette; a circular opening, instead of a rectangular doorway, giving a picture-like effect to the vista beyond. As these round doors are considered lucky, the evil spirit not being supposed to be willing to enter by them, there is always one at least of this form in every Chinese building. The gardens are cultivated with great taste and skill.

The houses of the lowest class are miserable and poverty-stricken, being nothing more than mud or crude brick huts, and covered with straw or rushes. The farm-houses are not much better, having generally a mud floor, and the apartments frequently being only separated by mats hung from the ceiling. The custom of plastering the inferior kind of houses with mud gives them a dingy appearance. Lime is a scarce commodity in the country, the only kind being prepared from shells and stones cast up by the sea.

The cities of China are by no means imposing in effect, as the surrounding walls are higher than the buildings they inclose—the Taas or towers being the only lofty structures. These towers are formed of several tent-like stories, diminishing in size as they ascend; and they are gaudily decorated, and hung with little tinkling bells at each angle of the many roofs.

The celebrated porcelain tower at Nan-king is of nine stories, forming a height of 216 feet; the roofs are covered with pale green glazed tiles, whence it derives its name. The pagodas are surrounded by courts and vestibules, the cells of which serve as a residence for the priests or bonzes. The Chinese have a great taste for gay and fanciful decoration: the glazed tiles of the roof are frequently arranged in the form of fishes' scales, and the pavements occasionally formed of shells laid in a pattern like mosaic-work. The timbers of the roof, which are always left exposed, are, in the habitations of the higher castes, formed of costly woods, or inlaid with ivory and mother-of-pearl.

As engineers, the Chinese were skilful in very early times; their bridges and canals bear as ancient a date as those of any of the great eastern nations, and that they were not ignorant of the art of building in its most solid and imperishable form, the Great Wall remains to testify. This stupendous undertaking separates China from Northern Tartary, and was completed about 214 B.C.; its length is computed at about 1500 miles; and a curious calculation has been made, that the materials of this wall, including the earthwork, would be sufficient to surround the world with two walls each six feet high and two feet thick. It is said that every third man in the kingdom was summoned to assist in its construction. It pursues a direct course over hill and valley, passing the rivers on arches; the only interruption is a ridge of lofty mountains in the province of Pe-tche-lee, and the broad river Hoang-ho. The foundation is formed of large stones laid in mortar; upon this is raised a mound of earth, cased in some places with brick, in others with stone. On the elevated ground it is only from 15 to 20 feet high, but along the valleys it is raised to the height of 30 feet. It is paved on the top with flat stones and is wide enough for six horsemen to ride abreast. In the valleys, and those places most open to attack, projecting towers are constructed within bow-shot of each other. Notwithstanding the enormous extent of this wall, it is said to have been finished in five years.—The Imperial or Grand Canal is a work of nearly equal magnitude, traversing a length of 900 miles.

There is so very little really interesting or instructive in Chinese architecture, that I shall pass on without further notice of it.

The countries of which mention has hitherto been made are contiguous, or nearly so, so that mutual intercourse and interchange of ideas has aided the progress of civilisation: I have now to speak of a far-off country, and to describe ruins that lie amidst the forest and jungle till lately unknown and unthought of, unless in the dreams of the poet.

"Man was in ancient days of greater mould,
And Hercules might blush to learn how far
Beyond the limits he had vainly set,
The dullest sea-boat soon shall wing her way;
Man shall descry another hemisphere.

* * * * * *

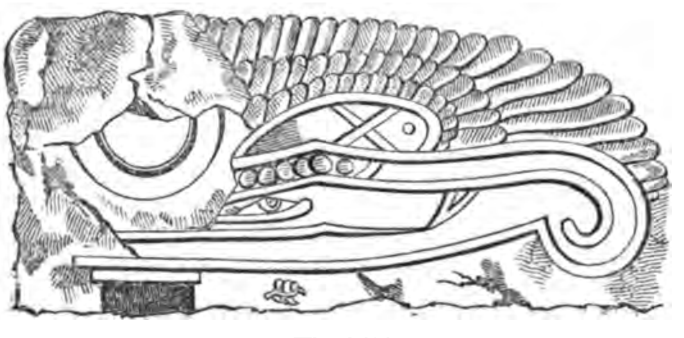
At our antipodes are cities, states,
And thronged empires, ne'er devined of yore."

—'Morgante Maggiore.'

Thus sang Pulci, while Columbus was either yet unborn or in his childhood, sailing toy boats on the bay of his native Genoa. Rumours had from time to time been afloat, of ruined cities in the midst of the trackless woods of Western and Central America; hunters and travellers had found masses of masonry and sculptured stones half hidden beneath the roots of the many-wintered giants of the forest: but these reports were long treated as travellers' tales, or as the result of a vivid imagination mistaking some curiously-shaped stone for the work of man's hand, where it was supposed man had never been. At last, exactly one hundred years ago, a party of Spaniards travelling in Central America, found unmistakeable ruins; and on examination, hewing their way through the dense forest, discovered the remains of a city, extending over 18 or 20 miles.

An exploring party was then sent out by the King of Spain in 1786, but either through jealousy or indifference, their report remained unpublished until the papers fell into the hands of an English gentleman at Guatimala, during the revolution of 1822. Still, doubts were thrown upon the authenticity of this narrative, and little interest was excited, until a paper appeared in the *Literary Gazette* in 1831, calling the attention of the public to the discoveries of Colonel Galindo; by this time, also, the celebrated Von Humboldt had travelled in Central America, and when his researches were published, scepticism was compelled to give way. Since then, many travellers have explored the country, and new discoveries have been made by Messrs. Stephens, Catherwood, Waldeck, and others; and already forty-four ruined cities have been brought to light in Yucatan alone.

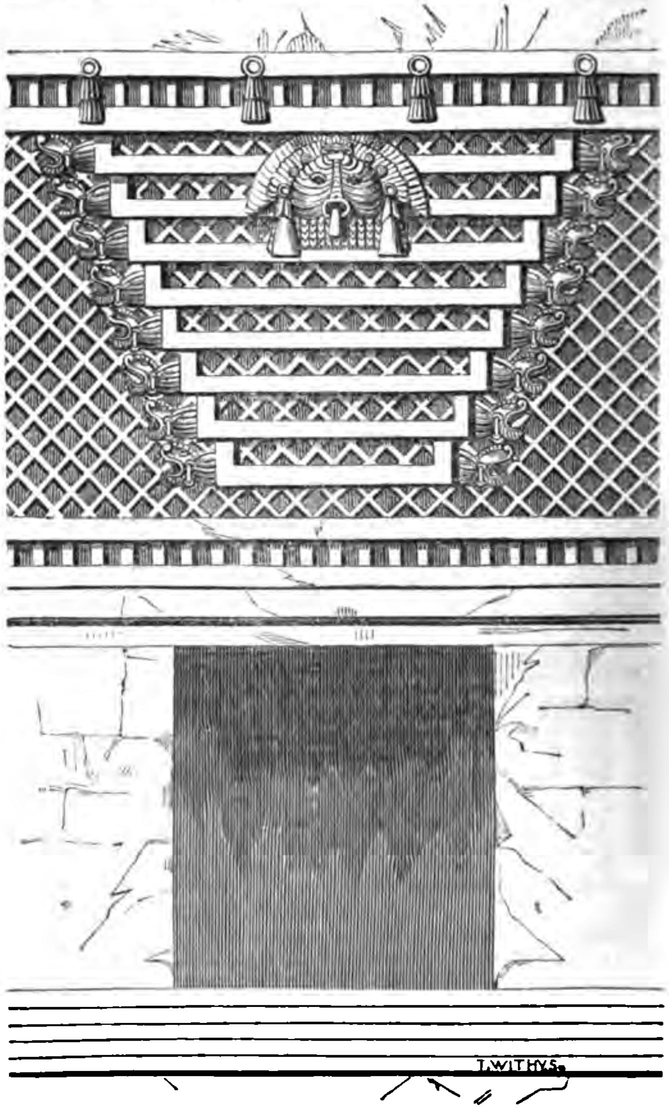
Naturally, where no certainty exists, each discoverer erects his own theory as to the date of this lost empire, and the race by which it was inhabited. At present, the most generally received opinion is, that these ruins are not so ancient as those of the Eastern world, and that they were living cities at the time of the Spanish conquest. The historian, Herrera, who accompanied Cortez in his expedition against Mexico, describes the natives as having a peculiar form of head, such as is represented on the sculptures, probably flattened back during infancy; and speaks of lofty terraces, ascended by flights of steps; of temples, magnificent palaces, and carved idols, all of stone. It is to be presumed, however, that as in our own quarter of the globe, cities fall into decay, while others rise in their neighbourhood, so in America some of the remains may be of a date anterior to others: the architecture of Palenque, for instance, appears to belong to an earlier period than that of Uxmal; and at the time of the conquest, though the Spaniards paused to erect a cross within two or three miles of Palenque, no mention is made of a populous city in the vicinity; most likely, therefore, it was already in ruins and hidden in the forest at the time they passed by.



Winged Globe.

The American Archæological Society have come to the conclusion that the first inhabitants were colonists from Tartary and Malacca; and it is thought they did not cross the ocean, but had wandered to the far north, and so overland to the new continent—successive races passing onwards, until they settled in the plains of Mexico and Yucatan. If this be the correct theory, it is singular how they could have supported themselves during their northern transit, and that they should have left no distinct traces of their footsteps by the way. Evidences of an Eastern origin are, however, not wanting: the winged globe is found over the doorways of Palenque, and the resemblance to the sacred symbol of Egypt is too exact to have been mere accident. Pyramids, too, and even mummies, have been found in Peru; and in the valley of the Ohio, tumuli have been found, containing conical domes of masonry, exactly the same as the "tholi" of the Pelasgians.

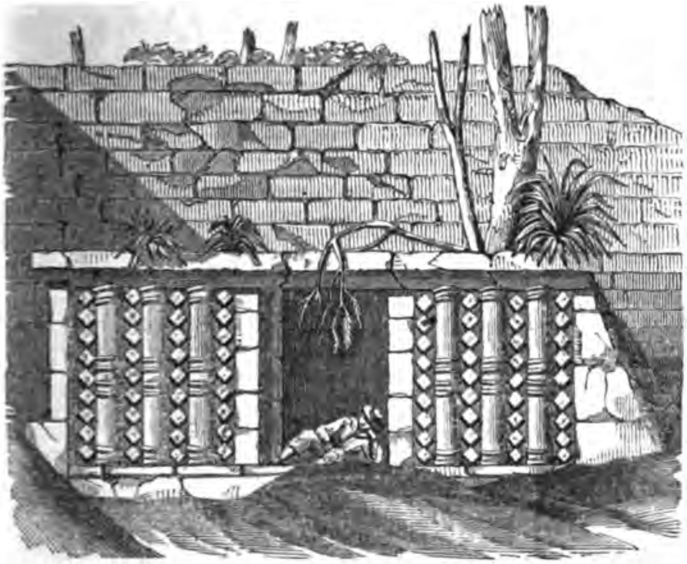
The rapid and rank growth of vegetation in that hot, damp climate may account for the state of utter ruin in which the most modern of these cities is found; but it is difficult to conceive (even allowing for the supineness of the Spanish Indians) how, in the course of a few generations, all record, all tradition of the past could so completely have disappeared: the hieroglyphics carved on the monuments are as utterly unintelligible to those whose great grandfathers must have spoken the same language, as are the Etruscan inscriptions after the lapse of nearly two thousand years. The only name the Indians have for the ruins, when even aware of their existence, is "*Casas de Piedras*," and the invariable answer to any question concerning them, "*Quien Sabe!*"



Portion of Façade from Casa del Gobernador.

In general appearance, the cities of Central America must have greatly resembled those of Assyria: like the Assyrians, this mysterious people built their temples and palaces upon high artificial platforms; those of America were of pyramidal form, ascended by wide flights of steps. At Uxmal, the platform upon which the principal building, called the Casa del Gobernador, is elevated is divided into three terraces, of the respective heights of 3, 20, and 19 feet; the lowest terrace is 600 feet in length, and the façade of the building on the highest terrace 320 feet in length. The steps do not always ascend in a direct line from the ground to the principal entrance of the building, but sometimes the first terrace is ascended by steps to the northern side,—while to arrive at the second the lower terrace has to be traversed half-way round, the next flight of stairs being found to the south: whether this plan was adopted for greater security, or from an idea of giving greater importance to the temple or palace by difficulty of access, it is hard to say. Occasionally, figures of great size, sculptured in bas-relief, have been found at each side of the steps. The principal flight of steps at Zayi is 32 feet in width.

The different cities would seem to have formed one great kingdom, from the similarity in architecture and the close resemblance of the sculptures and hieroglyphic inscriptions. The buildings are of stone, sometimes of one story, sometimes of two or three; when this latter is the case, each story recedes from the one below it, so as to give a pyramidal form to the structure. The façade is perfectly plain up to the moulding that runs along the top of the doorway; above this it is elaborately ornamented with carved work relieved on a painted ground. The style of decoration being barbarous and fantastic, the drawing of a portion of the façade of the Casa del Gobernador may serve to give an idea of the style: the grinning Gorgon's head in the centre calls to mind some of those on the antique Etruscan bronzes. Sometimes no general design has been adopted, but the façade covered with a kind of sculptured mosaic. In one instance, at Uxmal, the front of the building is divided into compartments by a bas-relief representing huge serpents intertwined like a rope; the compartments are occupied by figures of idols and other devices. Traces of paint are always found, the colours used being the same as in Egypt and Assyria. The façade is pierced by a number of doorways—sometimes as many as fourteen along the front of the building. These doorways are generallly mere rectangular openings, without moulding or other ornament; but, occasionally, rows of small columns or pilasters, not exceeding 6 ft. 6 in. in height, form the piers separating them. These columns are usually plain, with a square abacus; but at Kewick, as shown in the accompanying engraving, the attached pillars are ornamented with a binding round the shaft —reminding us of the description of Assyrian palm-tree columns, bound round with coloured bulrushes.



Doorway at Kewick.

The doorways lead into a corridor with a high vaulted roof, formed—in the same manner as among most ancient nations before the true principle of the arch was known—by horizontal courses of stones, projecting one over another till they nearly met, and then capped by a flat stone at the summit, the inverted steps being afterwards cut away: this method need not necessarily have been borrowed from the East, but would present itself naturally to all early builders in stone.—This corridor leads to an open court, surrounded by various apartments; in some of these courts an unhewn upright stone is found, which is supposed to have been a "kebla," or stone of observation, and to mark the site of a sacred edifice.

At Chichen there is an apartment with a flat roof, divided by transverse beams and supported by massive square pillars, like the interior of an Etruscan tomb; but, generally speaking, the buildings of ancient America differ more in the extent and number of the courts and corridors, than in style and arrangement. The masonry is beautifully wrought, the stones frequently polished and accurately fitted, though in some instances a mortar of lime and sand has been used. Near Copan, a quarry has been discovered in the midst of the forest, where many hewn stones are lying as if just ready to be removed.

The people of the Western world do not seem to have paid the same attention to the abodes of the dead as the inhabitants of the East: no sculptured tombs are found, nor are there any excavations, notwithstanding the proximity of rocks. A sepulchral pit was discovered at Copan, containing pots of red earthenware, many of which, according to Colonel Galindo, were full of human bones. Dishes and vessels of pottery have been found amongst the various ruins, and also images of terracotta. The images and idols are disproportionate, and hideous in the extreme, and appear calculated to excite feelings of repugnance and horror in the minds of the worshippers, rather than any sentiment of reverence or admiration.

There is a belief current in Yucatan, that amongst the mountains, in a region inaccessible to the white man, a city still exists, inhabited by the aboriginal race; and now and then a daring adventurer is said to have ascended a rocky peak, whence the gleaming walls and palaces of the mysterious town are visible—but none who have ventured beyond have returned to tell the tale. As the Indians say, "*Quien Sabe!*" The subject is as yet in its infancy; a wide field is open for discovery! and notwithstanding the dreadful climate, and fatigues and hardships to be endured in that wild country, doubtless there are daring spirits willing to follow in the footsteps of those who have led the way; and in a few years much may be brought to light, and perhaps all present theories and conjectures superseded by others founded on a surer ground of evidence.

I now proceed to the examination of a class of monuments more immediately interesting to us, as many of the most perfect are found in our own country. I mean those known as Druidical or Celtic remains. Among all the memorials of the past which time has spared to us, none are more wonderful than these: they exist everywhere—not only where the Celtic tribes are known to have permanently settled, but in Italy, Greece, Asia Minor, China, Persia, India, Egypt, and even in America. These monuments also tend to confirm the supposition, that at some period a similarity of worship has prevailed over the known world. They may be divided into five classes—viz. 1st, The Cairn, or carnedd; 2nd, The Maen-hir, or upright stone; 3rd, The Cromlech and Dolmen; 4th, The Kist-vaen, or stone chest; and, 5th, The Circle of stones.

The *Cairn* is simply a heap of stones, sometimes piled up in memory of any particular event, as in the covenant between Jacob and Laban,—sometimes as a sepulchral monument. When the cairn is unaccompanied by an upright stone, it is a sign that an infamous person lies beneath. To cast a stone upon a grave is an ancient mark of abhorrence—the sepulchre of Absalom is nearly choked up by the number of stones that have been thrown there in detestation of his memory. The tumulus, or barrow, on the contrary, was the most honourable place of burial; the kings and great men lay within these mounds, with their armour and weapons beside them. Frequently numerous skeletons are found in one barrow, which would seem to have been the cemetery for the surrounding population. In some places, several tumuli or barrows are grouped together. The word "tumulus" is from the Celtic root *tumba*—whence *tombeau* and tomb; "barrow" is from the Saxon *beorg* or *byrig*, and is applied indiscriminately to any mound of earth, whether intended as a fortification or a place of sepulture. The termination "bury" is taken from this word; and near any of our numerous towns ending in *bury*, some ancient earthwork invariably is, or has been found. The custom of burying within these mounds or heaps continued for many centuries after the Christian era, for we find a law of Charlemagne, in the ninth century, enacting that the bodies of all Christians shall be taken to the cemeteries, and not buried in the tumuli of the heathens. Heaps of stones are also piled as landmarks; they are placed on the hills in Scotland to guide the shepherds, and still receive the name of cairns.

The *Maen-hir*, the stones of memorial or observation, were generally placed upright as pillars. This setting-up of stones was the most ancient manner of commemorating any important fact; Jacob, after his memorable dream, set up the stone on which his head had rested, as a pillar (Genesis xxviii. 18); it is also recorded that after the discomfiture of the Philistines, the prophet Samuel "took a stone, and set it between Mizpeh and Shen, and called the name of it Eben-ezer" (Samuel, vii. 18): indeed, frequent mention is made of such stones of memorial throughout the Old Testament. In many places, a superstitious regard is still paid to them. In Iona there are several of these unhewn pillars, called "black stones," on account of the awful punishment supposed to follow the violation of an oath sworn upon them. These maen-hir were also used to mark the resting-place of the dead, though the Hebrews, like other eastern people, preferred a cave or excavation as a place of sepulture; when no rock was at hand, they made use of these stones of memorial: thus we read, that when "Rachel died, and was buried in the way to Ephrath," "Jacob set a pillar upon her grave: that is the pillar of Rachel's grave unto this day" (Genesis, xxxv. 19, 20).

It was a custom amongst the ancient Greeks to set an upright stone on the summit of a tumulus: it is, no doubt, in these stones of memorial that the head-stones in our modern cemeteries have originated. Upright stones were also used as a "kebla," or point of observation, to which the attention of the worshippers should be directed. Broad flat stones were used as stones of inauguration: the stone under the coronation chair at Westminster Abbey is of this description. It is supposed to be the same that stood upon the Hill of Tara, on which the kings of Ireland were inaugurated in ancient times. There was an old prophecy to the effect, that the same race should reign wherever this stone should be; consequently, when an Irish colony settled in North Britain, this stone was sent with them to confirm their dominion: it remained at Scone, where it formed the coronation chair of the Scottish kings, until the time of Edward I., who had it removed to Westminster Abbey, in defiance of the prophecy. Toland observes of this stone, that it is "the ancientest respected monument in the world, for although some others may be more ancient as to duration, yet thus superstitiously regarded they are not."

The *Cromlech* (from *crwm*, "bowed or inclined," and *llech*, "a broad flat stone") consists of a flat stone resting upon two or three uprights, with the upper stone generally inclining from the horizontal. The largest cromlech in England is that in the parish of Constantine, Cornwall: it is 36 feet in length, 19 ft. 8 in. in width, and 16 ft. 4 in. in thickness, its weight being about 750 tons. One of great size is also found at Plas Newydd, in the island of Anglesea. These cromlechs are generally supposed to have been altars, and are met with in every known country. It was a custom of the patriarchs to offer up their sacrifices at an open altar; we learn from the Talmud also, that before the erection of the tabernacle, religious rites were performed at open altars and on high places. The first mention in the sacred writings of a place set apart for worship was at Beersheba, where Isaac built an altar in the grove which his father Abraham had planted, and where he "called upon the name of the Lord" (Genesis, xxvi. 25.) It had been the custom from time immemorial to dedicate a grove as a place of worship; the rude hut or tent were too closely associated with the avocations of daily life, to become impressive as temples: the sultry climate of the east gave the inhabitants a great love and veneration for trees, which they naturally considered as amongst the most beautiful of God's creations, and they gladly retired to the umbrageous recesses of the grove to meditate and pray. On account of the idolatrous rites practised, the Jews were afterwards forbidden by their law to plant groves for worship; but in other countries, after the erection of temples, they were surrounded by a sacred inclosure, generally planted with trees, after the type of the altar in the grove.

We find the mention of unhewn stone altars in Exodus xx. 25: "And if thou wilt make me an altar of stone, thou shalt not build it of hewn stone: for if thou lift up thy tool upon it, thou hast polluted it." And again, in Deuteronomy xxvii. 5, 6: "And there shalt thou build an altar unto the Lord thy God, an altar of stones: thou shalt not lift up any iron tool upon them...Thou shalt build the altar of the Lord thy God of whole stones." Among the Romans, these unhewn altars or cromlechs went by the name of Fanum Mercurii. Strabo alludes to them in describing Egypt: he says that he saw on every hand altars of unhewn stones, composed of two uprights with a horizontal block across, and calls them temples dedicated to Mercury. Arrian informs us that similar altars existed in Asia Minor; and they are frequent in Italy:

> "Far off, concealed by pointed reeds, I'll stand,
> Or else beneath some altar, near at hand."
> ——Eclog. Third.

It is to be feared that under the Druids, these cromlechs were too often stained with human blood: in many of them basins are scooped out of the upper surface; and though these, as on the fire-altars of Persia, might be for a different purpose, the duct or channel leading from the basin to the edge of the stone, would seem to have been intended to carry off the blood of the victim. According to Mallet, 'Northern Antiquities,' in Sweden and Norway, they are still called "*blod*"—that is, blood-stones. Tacitus, in his account of the Isle of Mona (Anglesea), says that the Romans there cut down forests, in which the natives had been accustomed to practise the most cruel superstitions, making the altars smoke with the blood of their captives, and consulting the Divinity by inspection of the entrails of the victims; and Holinshed, speaking of places "compassed about with great stones round like a ring," adds, "But towards the south was one mightie stone, farre greater than all the rest, pitched up in manner of an altar, whereon their priests might offer sacrifices in honour of their gods."

The *Dolmen* (from the Celtic *taol* or *daol*, "a table," and *maen*, "a stone,") are nearly the same as cromlechs on a larger scale, excepting that the horizontal stone at the top is not inclined, but level, like (as its name denotes) a stone table: these are supposed to have served both as altars of sacrifice and dwelling places for the priests. The Fairy grottoes, or Fairy rocks as they are sometimes called, are dolmens of great size; some of these have the appearance of a corridor, ending in an irregularly-formed chamber; others approach the circular form, and a few are divided into two or three apartments. One of the most perfect of these constructions stands a short distance from Saumur on the Loire, and is called the Fairy Rock of Bagneux; the stones supporting the table are 7 feet in height; the outside width of the dolmen is 14 ft. 4 in, and the sides each composed of four stones, 57 ft. 6 in. in length. A single upright stone in the centre gives additional support to the roof or table. In this dolmen we see the original type of buildings in stone: the sides slope inwards to the roof, and the huge block of which this is formed gives the massive entablature; the builders would perceive that it was desirable to shelter the walls from the dripping of rain, and would place the horizontal block with its broadest side uppermost, so as to form an overhanging ledge; when they began to hew their stones, they would chisel this out smooth, leaving a ridge below to conceal the joining of the horizontal and vertical stones,—thus producing the most ancient form of moulding, the bead and cavetto: the first rude idea of an Egyptian temple would then be complete. M. de Fremenville mentions the remains of a dolmen on the shores of the bay of Morbihan, on some of the stones of which hieroglyphics were carved; but these have unfortunately been destroyed.

Fairy Rock of Bagneux.

The *Kist-vaen*, or stone chest, is a sort of rectangular cell, formed by a flat stone resting upon three uprights composing the three sides, the fourth side being left open. They are supposed to have been sepulchres, and also places of initiation. One of the best specimens is in Kent, and is now called Kit's Coty House: Camden supposes this monument to have been erected over the tomb of Catigern, an ancient British hero. In Wales there is a circle composed of several kist-vaens, with a cromlech in the centre; under the kist-vaens human bones have been found.

The *Circles of stones* were sacred inclosures and places of public meeting, either for civil or religious purposes. These are also found in various countries: a circle of stones, with an upright stone in the centre, still exists near Darab, in Persia; and it is said that three circles have been found in America. Cæsar informs us that the Druids in Gaul sat in a consecrated place at certain times of the year, when people flocked together from all parts of the country. Here judgment was passed upon criminals, rights of inheritance and boundaries of land established, and disputes, public and private, settled by a decree to which all submitted. In Iceland these circles are called "*domr ringr*," that is, "doom rings," or circles of judgment. In an ancient Welsh poem we find the following allusion to these consecrated inclosures: "Bards were constituted the judges of excellence, and bards will praise thee, even Druids of the circle;" and in another passage the poet says, "It is my right to be master of song, being in a direct line of the true tribe, a bard of the inclosure."

Of these sacred circles, Stonehenge is the largest and most perfect, and has from time immemorial been considered one of the wonders of the world. The name is derived from the Saxon *stan*, "stone," and *henge*, "hanging," or as some translate it, the "stone gibbet," in allusion, I suppose, to the huge trilithons forming so conspicuous a part of the ruins. This temple (for so it may be called) consisted originally of two circles and two ovals, which latter formed the sanctuary; the outer circle was about 300 feet in circumference, and was composed of lofty upright stones, with others placed across to form a kind of architrave. This circle consisted formerly of 30 stones, of which 17 remain standing. Within this is another circle, composed of small unhewn stones. The largest oval was formed by five pair of trilithons; the highest one now standing is 22 ft. 6 in., but one that has fallen and broken measures 26 ft. 3 in. The horizontal stones are attached to the uprights by joggles. According to Dr. Stukeley, the inner oval was composed of 19 stones. The altar stone is 16 feet in length, but is almost covered by the fall of one of the great trilithons. The whole structure was surrounded by a "vallum," 369 yards in circumference; and here we find an instance of the distinction made in ancient earthwork between the military and civil or religious structures—in the former the ditch is outside the rampart, and in the latter invariably within. There is many a tradition connected with Stonehenge, but no positive history. Hecatæus of Abdera, an officer in the army of Alexander the Great, in his history of the Hyperborean nations, speaks of a "temple of the sun," in evident allusion to Stonehenge. It is also mentioned by the Welsh Bards: in one of their songs, the "stone cell of the sacred fire" is celebrated, and is considered as the great sanctuary of the dominion. It is curious to meet with these constant allusions to sun and fire worship—another proof of the prevalence of some primitive and universal faith. In Ireland, there is a rock with a basin scooped out of its upper surface, that goes by the name of *Carig-Croith*, the "rock of the sun." Sacred stones, such as those of Stonehenge, were distinguished by the ancients by the name of "amber," signifying anything solar or divine: hence, Stonehenge was sometimes called "Maen-amber," and gave the name of Ambresbury, now Amesbury, to the nearest town. Giraldus Cambrensis, who lived in the middle of the twelfth century, calls these stones "the Giants' Dance," and says they were brought by giants from Africa, and set up in Kildare; they were afterwards removed from Ireland to Salisbury Plain by the power of the enchanter Merlin. Jeffrey of Monmouth, who wrote in the same century, also relates the tradition, as follows:—"Aurelius, wishing to commemorate those who had fallen in battle [speaking of a battle between the British and Saxons], and who were buried in the convent of Ambresbury, thought fit to send for Merlin the prophet, a man of the brightest genius, either in predicting future events or in mechanical contrivances, to consult him on the proper monument to be erected to the memory of the slain. On being interrogated, the prophet replied, 'If you are desirous to honour the burying-place of these men with an everlasting monument, send for the Giants' Dance, which is in Killarœus [Kildare], a mountain in Ireland; for there is a structure of stones there, which none of this age could raise without a profound knowledge of the mechanical arts. They are stones of a vast magnitude and wonderful quality; and if they can be placed here, as they are there, quite round this spot of ground, they will stand for ever.' At these words, Aurelius burst into laughter, and said, 'How is it possible to remove such vast stones from so distant a country? as if Britain was not furnished with stones fit for the work!' Merlin having replied that they were mystical stones, and of a medicinal virtue, the Britons resolved to send for the stones, and to make war upon the people of Ireland if they should offer to detain them. Uther Pendragon, attended by fifteen thousand men, was made choice of as the leader, and the direction of the whole affair was to be managed by Merlin. On their landing in Ireland, the removal of the stones was violently opposed by one Gillomanius, a youth of wonderful valour, who, at the head of a vast army, cried, 'To arms, soldiers! and defend your country: while I have life, they shall not take from us the least stone of the Giants' Dance!' A battle ensued, and victory having decided in favour of the Britons, they proceeded to the mountain of Killarœus, and arrived at the structure of stones, the sight of which filled them with both joy and and admiration. And while they were all standing round them, Merlin came up to them, and said, 'Now try your forces, young men, and see whether strength or art can do more towards the taking down these stones.' At this word, they all set to their engines with one accord, and attempted the removing of the Giants' Dance. Some prepared cables, others small ropes, others ladders for the work,—but all to no purpose. Merlin laughed at their vain efforts, and then began his own contrivances. At last, when he had placed in order the engines that were necessary, he took down the stones with an incredible facility, and withal gave directions for carrying them to the ships, and placing them therein. This done, they with joy set sail again to return to Britain, where they arrived with a fair gale, and repaired to the burial-place with the stones. When Aurelius had notice of it, he sent out messengers to all the parts of Britain, to summon the clergy and the people together to the mount of Ambrius [Ambresbury], in order to celebrate with joy and honour the erecting of the monument. A great solemnity was held for three successive days; after which, Aurelius ordered Merlin to set up the stones brought over from Ireland, about the sepulchre, which he accordingly did, and placed them in the same manner as they had been in the mountain of Killarœus; and thereby gave a manifest proof of the prevalence of art above strength."

Aurelius Ambrosius succeeded Vortigern in the year 465 A.D. Aylett Sammes, who wrote in 1676, refers Stonehenge to a Phœnician origin, thus explaining the legend of the African Giants; and it is singular that the stones of which Stonehenge is principally composed are called "sarsen-stones," *sarsen* being the Phœnician word for "rock:" it is a common saying amongst the Wiltshire peasantry, "As hard as a sarsen." Numerous stones of the same formation are scattered over this part of the county, and on Marlborough downs are strewed about so thickly, as to gain for the place the appellation of "Grey wethers," the stones in the dusk of the evening appearing like an immense flock of sheep. According to Dr. Stukeley, a tablet of tin was found at Stonehenge in the reign of Henry VIII., inscribed with strange characters that none of the antiquarians of that age could decipher. James I., in 1620, employed the celebrated architect, Inigo Jones, to collect information concerning Stonehenge; who came to the extraordinary conclusion that it was of Roman origin,—but this singular opinion does not need refutation. From all these authorities, it will be seen how very little is known respecting this wonderful structure: in fact, all the information we possess respecting it amounts to this—that such a pile *was* erected near Amesbury, and that it was considered a marvellous work by our most ancient authors.

Another extraordinary temple stood 19 miles distant, at Abury, of the form of a serpent transmitted through a circle—according to Dr. Stukeley, a hieroglyphic of the highest note and antiquity. The serpent was greatly venerated amongst the ancients, being considered a symbol of renovation or immortality, on account of its annually shedding its skin. When temples were built in this form, they were called Dracontia. Serpents were constantly introduced on antique altars and coins. The temple of Abury was constructed of huge unhewn stones; the great circle was inclosed within a vallum of 1400 feet in diameter. The two serpentine avenues of upright stones, called the Kennet and Beckhampton avenues, forming the neck and tail of the snake, were each a mile in length; the Kennet avenue ended in a small circle of stones on Overton-hill, formerly called Hackpen, from the Saxon words for snake-head. The whole construction is supposed originally to have consisted of 650 stones. Mr. Aubrey, who lived in the reign of Charles II. was enabled to make out the whole plan of the temple from existing remains; he has left a description of it in manuscript, which he refers to the following source: dated 1663 A.D. "King Charles II. discoursing one morning with my lord Brounker and Dr. Charlton concerning Stonehenge, they told his Majestie what they had heard me say concerning Aubrey (or Abury), for that it did as much excel Stonehenge as a cathedral does a parish church. His Majestie admired that none of our chorographers had taken notice of it, and commanded Dr. Charlton to bring me to him the next morning. I brought with me a draught of it, done by memorie only, but well enough resembling it, with which his Majestie was pleased, gave me his hand to kisse, and commanded me to waite on him at Marleborough, when he went to Bath with his queen (which was about a fortnight after), which I did; and the next day, when the court were on their journey, his Majestie left the queen, and diverted to Aubrey; with the view whereof, he and his royal highnesse the Duke of Yorke, were very well pleased. His Majestie then commanded me to write a description of it, and present it to him; and the Duke of Yorke commanded me to give an account of the old camps and barrows in the plains."—Since the time of Mr. Aubrey, the destruction of this fine memorial of past ages has been complete; the stones of which it was composed having been broken up to serve as building material for the modern village of Abury, situated within the ancient vallum. The snake-head remained till within a few years, when the farmer on whose land it stood had the stones removed and the ground ploughed over.—Numerous small circles of stones are met with in England and elsewhere, but do not require any particular description.

I shall leave the mention of the camps and cities of our Celtic and British ancestors to a future period, and shall invite the student, in the next Lecture, to return with me eastward, to consider the Pelasgic remains of Greece and Italy, the architecture of the Jews, and the ancient remains of Asia Minor.

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ENGINEERING EMPLOYMENT.

In our former article (p. 26) we made some remarks on engineering employment, and the opening there is in agricultural operations. Since then, Mr. Cubitt, on taking the chair of the Institution of Civil Engineers, and making his presidential speech, has taken up the same subject (*vide* p. 41). We have latterly been under a dearth of work, from the slackening of railway undertakings; but it is to be hoped, with the awakening of trade throughout the world, we have a better time before us. Nevertheless, there is one great duty on every member of the profession, and that is, to uphold it. What the members of the Institution bind themselves to do, every member of the profession should likewise undertake. Let each do something to increase the field of knowledge, and let each do something to increase the field of employment, for by keeping up the common interests, so is the interest of each best kept up.

The lawyer, being a trained man of business, has laid hold of a wide field of employment. Although litigation is very profitable, yet with the higher solicitors it forms but a small part of their emoluments; they are the chief counsellors of the landowner and the trader, in all money matters. They are agents for boroughs, stewards for manors, advisers as to lending and borrowing money, as to buying estates and selling them, marrying, settling, and willing away. The counsellor who has a bosom knowledge of a man's business, has a share in his well-being, and becomes his friend as well as his adviser; knit up in the same undertakings, and having the choice of every enterprise as well as the immediate reward for professional exertions.

Men of property want, however, other advisers. The man of law has no time for geology or chemistry, bricks and mortar, or earthwork; these are what the engineer can undertake, if he will but put himself in the way of doing so. The beginning of the connection, however, is everything, and the reward to be looked for is not immediate but permanent. It will often happen in our professional pursuits, as with the lawyer, that what costs us most labour is of least worth to our client; and whatever we may set up as to the labourer being worthy of his hire, modern political economy is much fonder of another saw—that a man shall not be asked to give more for anything than it is worth to him. In one year the lawyer may do much work and get small pay; in the next he may do little, and yet have the means of making the highest charges. Nothing can be so valuable to a client as a proceeding by which a costly litigation may be saved; and yet the attorney may not be able, by putting in all the conventional "six-and-eightpences" he can, to screw up his bill to more than a pound. So with the engineer, he may make half-a-dozen plans, and only one be adopted, though unquestionably the time for all six is spent in the work. On the other hand, the landowner cannot afford to pay for five plans which are not worth a farthing to him.

The merchant, if he knew he could have the services of an engineer on moderate terms, would often refer to him—but the landowner has still greater need of such help; and it is to be remembered there are small landowners as well as great ones, as there are small traders as well as great ones. There is very little difference in the amount of talent and exertion required between a little plan and a great one, but there is very much difference between the means of remuneration; and this is what we want the engineers, and particularly the young ones, to bear in mind. Professional etiquette is a very fine thing; but what is called professional etiquette in most professions is, like trades' unions among mechanics, only a means of increasing the monopoly for the big men, and rewarding the lazy and stupid from the earnings of the hard-working.

Here we will stop a while for a few words on "professional etiquette," which may in most cases be put in the common tongue as "professional remuneration." Engineering is now acquiring a professional organisation, and the time is near when the questions of a professional test and professional etiquette will spring up, and be worked to the injury of the profession, unless the members take heed. Engineering is now an open profession, taking talent from every quarter—from the coal-heap, the mine-shaft, the quarry, and the work-bench, no less than from the desk and the college; and it is to be hoped no coxcombry will ever be allowed to alter this state of affairs, but that the field shall be free to all, and, above all, to the working man; and be it remembered, that after all that is said, this is the only field of ambition open to the ingenious mechanic. The architects are mooting this matter of professional test, and some of them want to have certificates; when, if they could see their true interest, they would throw open the field for admission, and invite more talent—whereas they actually propose to shut out some of what they have, and have a ridiculous regulation to cut off the surveyors from their body. As it is, the architects are being driven out by the engineers, who have no restrictions; and the struggle will be still less doubtful when it is the few articled pupils against the talent of all England enrolled among the engineers. Hitherto the architects have had the government patronage, certain official appointments, knighthoods, a share in the Royal Academy, and other good things. Notwithstanding this, the engineers have beaten the architects in public estimation; and notwithstanding the engineers have had the hostility of the government, who have defrauded them of the public appointments due to them, and put military officers and corporals in their places.

Professional etiquette or professional remuneration means that there shall be a certain scale—that a young man shall not charge lower than an older one, and consequently, that the older one, who is known, may be employed in preference to the younger one, though the latter may have the talents of a Watt or a Stephenson. As this doctrine is set up on a wrong economical groundwork, it always works ill. It looks to the interest of the professional man, and not to the means of his employer; and the class most injured is therefore that of the professional men. Take the case of a solicitor who has to deal with a uniform scale: many kinds of business he cannot undertake, and for many he can get no proper remuneration, because the scale has no reference to the benefit done to the employer, but only to the work done by the lawyer. Take the case of the medical men, who, by the results of professional etiquette, have pauperised the working classes of this country, keep up dispensaries for the benefit of "pure" physicians and surgeons, and the demoralisation of the out-patients, and who lose, on the lowest estimate, a million a-year, which they might obtain by small fees from the labouring classes. In France, a young man can begin with a shilling fee, and he goes on increasing his scale as his practice enlarges, so that we believe at Paris the highest medical remuneration is higher than in London. So among artists, they may begin with a shilling or half-a-crown, until their lowest charge is two hundred guineas.

There is many a man with three or four hundred acres, who would like to know what he can do with them for the best; for unless he keeps a sharp look out, his rents are likely to be much lessened—not by free trade, but by protection and agricultural ruin; a war-cry which the farmers having been once taught by the landlords themselves, are not likely to give up without getting something by it. The farmers have already screwed down their workmen, and they are trying their hands with the landlords to get something off their rents. A landowner with a small holding, cannot afford to send for a great engineer, or an engineer who wants a great fee; but he would be very glad to have sound advice as to what can be done. If he has minerals underground, that ought to be known,—if clay or lime aboveground, he will think about tile or lime kilns. A fair analysis of the soils is to be made, to know whether anything is wanting in them, and whence it is most readily to be got. The streams of water must be looked after, and it must be settled what is to be drained off, and what can be kept for catchwater meadows, or to feed the crops. It may be worth while thinking whether wells should not be sunk, to water the cattle where the land drainage is not wholesome. The roads settle the number of draught horses to be kept; and a few yards of quagmire filled up will perhaps get rid of half the horses. The hedges, trees, buildings, machinery, dung-pits, must be looked to, mapped out, and reckoning gone into as to what is to be done with them.

A great landowner can send for Mr. Parkes, or Mr. Smith of Deanston to plan works, Mr. Bailey Denton to lay down a survey, Prof. Phillips to examine his minerals, and Prof. Johnston to analyse the soils; but the small landowner wants this done by one man, at a small rate. The farmer, or the schoolmaster who is a land-surveyor, can plot out the ground—but there he ends. There are many farmers and land-valuers who can give very good advice as to draining or laying out the farm buildings; but still they cannot do the whole work. A young man who has been fairly brought up can do all that is wanted. He must be a surveyor, engineer, geologist, and chemist: know how to plan and estimate buildings; but, above all, he must be a good accountant—one of the first qualifications of a man of business.

The engineer is becoming the counsellor of his employers in many great undertakings, and his success will be much dependent on his knowledge of business. Now, so far as we know, in the engineering schools, book-keeping is not taught, and neither is political economy. We ought perhaps to go further, and say that logic and the training of the mental powers are not taught. The technical knowledge of accounts is needful to every engineer who would be more than a mechanic, for our's is a truly practical profession; and without knowing what the outlay will be, and what the income, a man who lays down a plan is a mere bubble-blower, and may as well lay down a bridge from Dover to Calais, for which the gold diggings of California would never pay,—or set up a patent cabbage-cutting machine, such as that which saved one cabbage in a hundred, but trampled down four. For want of a knowledge of higher political science, engineers are unable to grapple rightly with all the bearings of the plans which come before them. In common arithmetic, two and two make four; but in political arithmetic, they may make five, four, three, or even two.

An engineer who is called in to look over land is not called in to spend money, but to save it. He must look to the means of his employer. If the latter is short of money, then only those works must be set about which are altogether needful: if, however, he has money to spare, then it is worth while to lay it out in every way which will bring a good return. Everything must be well reckoned up. The whole mileage of carts and horses throughout the year, must be worked out,—whether this can be shortened, whether lighter carts can be run, or other kinds of ploughs be brought to bear. When buildings are to be set up, it does not follow they are to be built off-hand of brick or stone; but it must be worked in every kind of way, to make the most of the stone, brick, timber, and lime at hand. To liken great things with small, if railways had been so worked, they would now yield a much better income.

A farm is a factory for bread and meat, and is to be set up in the same way as a cotton-mill. The engineer is the man to undertake the task, for neither landowner nor farmer can do it without him. One set pattern does for a windmill or a baker's oven, but no two farms are alike. One is high, another low; one wet, another dry; and so forth; and there must be a plan for each.

This constitutes the protection of the engineer, for if a plan could be stereotyped and lent about from landowner to landowner, as a crotchet pattern by their wives, small would be the extent of engineering employment. It is on the degree of skill displayed in each design, in its peculiar and specific application to the circumstances, that the engineer must depend for his reputation. If he contents himself with copying from books, or with mixing up stock plans, either in this or any other branches of engineering employment, he is only undermining himself, for his employers can do the same thing, or others can start against him.

We repeat, that protection is not to be sought in a code of conventional etiquette, but by the upright discharge of professional duties towards employers, looking not to selfish emolument, but to mutual advantage where a mutual service is rendered, and where a mutual interest is at stake. Those who hire themselves out for the day will be treated as hirelings: those who do unto others as they would others should do unto them, will be treated as friends, and rewarded as such.

ON THE LIFE AND GENIUS OF VIGNOLA.

On the Life, the Genius, and the Works of Giacomo Barozzi Da Vignola. By SAMUEL ANGELL, Esq., Architect.—(Paper read at the Royal Institute of British Architects, Feb. 4th.)

Of the great Italian architects of the sixteenth century, I doubt whether there is one to whose works and instruction we are more indebted than to him, who forms the subject of the present paper, Giacomo Barozzi da Vignola. We have all probably our different favourites among these great masters—one preferring the grandeur and solidity of the San Galli; another, the refined elegance of Peruzzi; a third, the harmony and simplicity of Palladio; but for a happy combination of exquisite grace, with originality and purity of design, I consider Vignola as deserving the palm.

In France the merits of Vignola have always been justly appreciated. The architect is there taught from the commencement of his studies to revere him as his law-giver, and his name has given the title to several of the French elementary works. They have their 'Vignoles des Architects,' 'Le Vignole des Ouvriers,' and 'Le Vignole des Proprietaires.' They have produced 'Le Vignole in fol.' and 'Le Vignole de poche;' in fact, for pure Italian architecture this great master is looked up to as their standard, and I believe I am correct in attributing the great excellence of modern French architects to the fortunate selection they have made of Vignola as their chief guide and instructor.

Of our own countrymen, Sir William Chambers has, perhaps, been the most forward in doing justice to the merits of Barozzi. In Sir William's admirable treatise he constantly refers to the writings and executed works of his great Italian prototype, and in his Five Orders he has drawn more largely from Vignola than from either Scamozzi, Serlio, or Palladio.

Our Honorary Foreign Secretary has also done justice to the genius of Vignola in the following passage, from his instructive work on Doorways:—"We are not sufficiently acquainted in this country with the powers of Vignola's mind, which is more to be regretted, as all his works evince a profound knowledge of the resources of his art, and a taste of the most cultivated and refined nature. Grace is the predominating feature in all his buildings, not one of which but is sufficient to establish the reputation of any man."

Before I proceed to discuss the merits of Vignola as an architect, I will first slightly glance at the history of his life, and describe some of his principal works. Of the former I have little to add to what is contained in his memoir by Vincenzio Danti, as well as in Milizia's 'Memoire degli Architetti;' and also in the accounts prefixed to the editions of his works, well known, no doubt, to those present. And although I can offer no such amusing scenes, nor stirring events as are to be found in the life of a Benvenuto Cellini, still the career of Vignola was not without its shadows: occasionally basking in the sunshine of royal favour and pontifical patronage, there were times when he despaired of success, and when he found it necessary to change the intent and nature of his studies.

Vignola was born on the 1st of October, 1507; his father, Clemente Barozzi, was of a noble family, and a native of Milan; his mother was a German lady. The civil wars of that period obliged Clemente to leave Milan, and he took refuge in the small town of Vignola, in the Modenese states, and Giacomo being born there, was, according to the custom of those days, surnamed after the place of his birth.

Clemente Barozzi died during the infancy of Giacomo, who, as he grew up, evinced some talent and inclination for drawing, and was therefore advised to proceed to Bologna to study the art of Painting and Design. He does not, however, appear to have made the progress in his pursuits that he desired, he therefore took the resolution of changing them for Perspective and Architecture; and in these, his more congenial studies, he soon arrived at that proficiency which his natural genius and constant application enabled him to attain. Francesco Guicciardini, at that time governor of Bologna, took him under his patronage, but the youthful Vignola, perceiving that a thorough knowledge of architecture not merely consisted in making designs, or studying the works of Vitruvius, determined to proceed to Rome, and there to measure and study those glorious remains of ancient magnificence for which he had so profound a veneration.

He at first obtained employment by making drawings for Melighini of Ferrara, the same unfortunate wight, who, it is said, served his holiness in capacity of groom, and who, upon the occasion of the competition for the *Cornicione* of the Farnese Palace, was called by Antonio Sangallo "that mountebank of an architect." The necessity of procuring the means of subsistence obliged Vignola occasionally to resort to painting small pictures for sale, but this precarious mode of life was so distasteful to him, that upon the formation of an Academy of Architecture in Rome, by Monsignore Marcello Cervini (afterwards elevated to the papal chair), he gave up painting and devoted himself entirely to the study of architecture, drawing and measuring nearly all the then existing remains for the use of the academy, and to the entire satisfaction of its members.

About the year 1537, Vignola left Rome in company with Primaticcio, the painter, who took him with him to France, and presented him to Francis the First, to whose service he became attached as professor of design. He made several drawings of ancient monuments for that great monarch, and various designs, the execution of which was prevented by the wars and troubles of that period. Some of his designs in perspective are said, however, to have been executed upon the walls of the palace at Fontainbleau. Vignola appears also to have assisted in casting in metal several statues from the antique for that palace, but Francis the First, having other occupations and demands upon his time and treasure, was obliged to withdraw his patronage from the fine arts, and our architect therefore returned to Bologna at the invitation of Count Filippo Pepoli, president of S. Petronio, and he was engaged up to the year 1550, in making designs for that establishment.

Competition designs in the sixteenth century do not appear to have been managed with more satisfaction to the parties engaged, than in the nineteenth: and Vignola is said to have been troubled with many dissatisfied rivals, when Giulio Romano and Christoforo Lombardi being called in to advise (much in the same way as in our own times) upon the designs sent in for the restoration of S. Petronio, Vignola's was adjudged by those two great artists to be the most meritorious. This account, however, does not quite agree with Giorgio Vassari's statement, in his life of Giulio Romano, from which it would appear that Giulio Romano himself made a design for the façade, which was much admired by the Bolognese. Palladio made four designs, and Baldassari Peruzzi and Alessi were among the competitors. The affair appears to have created a great sensation in the architectural circles throughout Italy at that period. These designs are still preserved in the Reverenda Fabrica, at Bologna (adjoining S. Petronio); they were seen by Mr. Falkener and Mr. Newman last year. Vignola's design is of a Gothic character, in accordance with the other parts of the building; it does not appear so meritorious as Giulio Romano and Lombardi adjudged it to have been.

We gather from Milizia, that it was the custom at that time to consult the chief architects of the day upon any questionable point of design or practice, for in a dispute between Bassi and Tibaldi upon some matter connected with the works in progress at Milan Cathedral, Bassi applied for the advice of Palladio, Vignola, Vassari, and Bertani: and Milizia remarks that the answer of Vignola as respected the Baptistery was well worthy of being recorded. Tibaldi, in order to support his ill-proportioned intercolumniations, proposed to introduce iron chains, Vignola remarked, "*Che le fabbriche non si hanno da sostenere colle stringhe,*"—"a golden sentence," as is well observed by the ingenious and learned author of the 'Notitia.'

Vignola appears about this period to have been employed upon a palace at Minerbio, for the Conte Alemano Isolani, and upon a house for Achille Bocchi, in Bologna: upon the Façade dei Banchi in that city; and upon the Canal of Naviglio, a work of engineering, which architects then undertook as a legitimate part of their profession.

My friends, Mr. Edward Falkener, and Mr. Newman (both of whom have lately returned from Italy with rich stores of architectural study) were induced, from finding the palace at Minerbio described as a great work of Vignola's, to make a detour of some twenty miles to see it, and we may judge of their disappointment upon finding the only work of Vignola's now existing at Minerbio to consist of a Columbajo, of an octagon form, about 25 feet in diameter, and 70 feet in height. No traces of the palace could be found; but if that building was in proportion in extent of accommodation to the Columbajo, which would contain 13,000 pigeons, it must have been a building of no little magnitude.

Upon a second visit to Rome, Vignola was introduced by Giorgio Vassari to the Pope Julius III, who, when legate at Bologna, was acquainted with Barozzi. His holiness appointed him as architect, giving him the direction of conducting the Acqua di Trevi, and commanding him to make designs for his celebrated residence, the Villa Papa Giulio; he was also engaged upon the small neighbouring Church of S. Andrea a Ponte Molle.

The Cardinal Alessandro Farnese was a most influential patron of Vignola's. He employed him upon that portion of the Farnese Palace known as the Caracci Gallery, and his hand may be traced in other parts of this celebrated building. He was engaged at the Cancellaria; and he also designed for the Cardinal the exquisite gateway to the Orti Farnesiani in the Campo Vaccino. The greatest work, however, upon which this powerful prelate employed him, was that superb specimen of architecture, the palace of Caprarola.

At the decease of Michael Angelo, in 1564, Vignola was appointed architect to St. Peter's, and to his refined taste we are indebted for the two beautiful lateral cupolas of that building. The Church of the Gesù in Rome was also a commission from the Cardinal Alessandro Farnese; the foundations were laid in 1568, but the works were only carried up to the height of the cornice by Vignola. The building was completed under the direction of Giacomo della Porta.

The great Ducal Palace at Piacenza was designed by Vignola, but completed by his son Giacinto. A chapel in the church of San Francesco in Perugia, the Capella Ricci in Santa Caterina de' Funari at Rome, the church of Santa Anna dei Palafrenieri, the Oratorio di San Marcello, and the tomb of the Cardinal Ranuccio Farnese in San Giovanni Laterano, were among the works of Vignola about this period; and he was also employed upon several public and private edifices in various parts of Italy, among which were the Chiesa della Terra di Manzano, that of S. Oreste (Mount Soracte), and Santa Maria degli Angeli at Assisi.

The foundations of the Palace of the Escurial were laid in 1563, when the Baron Martirano being at the court of Philip the Second, and being much esteemed by that monarch as of acknowledged taste in the arts, he was consulted in respect of this important building, and commissioned to return to Italy to advise with the most celebrated architects of the day,—Galeazzo Alessi at Genoa, Pelegrini Tibaldi at Milan, Palladio at Venice, and the Academy of Design at Florence. The grand duke Cosmo di Medici also ordered a design to be made by Vicenzio Danti. No less than twenty-two designs from different architects were collected on this occasion; but it is stated that none were so well received by the King of Spain and Martirano as that by Vignola, who, having had all the designs sent to him for his inspection and judgment, selected the best parts of each, and thus dressed up a description of *olla podrida* design for his most Catholic Majesty. This at first sight does not appear to have been a very creditable proceeding on the part of our architect, but at this distance of time it would hardly be just to venture a censure without having all the circumstances of the case before us; and as the character of Vignola for honour and integrity has never been impeached, it is only fair to presume that he did nothing unworthy of it in this transaction. Philip invited Vignola to proceed to Spain to superintend the execution of his design, but finding himself advancing in years, and being much occupied with his professional duties (more particularly with those pertaining to St. Peter's), he prudently declined the royal invitation, and determined upon continuing in his favourite Rome. The Escurial, according to Milizia, was afterwards erected by Giovanni Battista of Toledo, who commenced the work in 1563.

In the year 1573, Vignola was invited by Pope Gregory the Thirteenth to proceed to the city of Castello to examine into a disputed question of boundary between the Tuscan and Papal States; and although suffering greatly from indisposition at the time, he obeyed the pope's commands, and fulfilled his commission with care and great judgment. Upon recovering his health he immediately returned to Rome, and sought audience of the pope to render him an account of the successful performance of his commission; he remained an hour discoursing with his holiness upon the subject, and upon the state of the progress of several buildings from his designs, and received permission to proceed on the following day to Caprarola; but during the night he was attacked with fever, which terminated in his death after six days' continuance.

Vignola died on the 7th July, 1573, at the age of 66; he had requested to be buried in a private manner, but his son Giacinto was obliged to concede to the wish of his friends and admirers, and he was interred with great pomp in the Pantheon, all the members of the Academy of St. Luke attending the ceremony, as a tribute of respect to his memory.

Ignazio Danti (to whom we are indebted for a Memoir of the Life of Barozzi) makes most honourable mention of his noble and generous disposition. His constant desire was not to be burdened with the cares of superfluity, or the miseries of want: his numerous charities prevented the former, and his talents and the extensive patronage he enjoyed rendered him exempt from the latter. His life was most virtuous! his love of truth proverbial! his manner cheerful and engaging! his accomplishments refined! He died poor, leaving no other inheritance to his son Hyacinth (observes Quatrèmere de Quincy) "than the example of his virtues and the reputation of his name!"

Milizia states that Giacomo della Porta studied under Vignola, and Bonanni styles him as *discipulus ejus;* he succeeded him as architect to St. Peter's, and also designed and executed the several churches and other important works in Rome.

I regret that I am unable to give the date when Vignola produced his celebrated Treatise upon Architecture. Daviler and Milizia both state that it was towards the latter end of his life, and this is in some measure confirmed by Vignola himself, who, in the following passage from his modest and unpretending preface says, "that having for many years practised as an architect in various parts, having studied the writings of several authors upon architecture, and having compared them together and with the works of antiquity then still remaining, he was desirous of establishing a rule upon which he might rely with security, and which might, upon the whole, or in part, please the judicious."

Of a treatise so well known to architects it will be unnecessary for me to offer any description, it being sufficient to observe that its merits have now been tested for more than three centuries; that of the parallels, which have been made of the orders with those of such powerful rivals as Serlio, Scamozzi and Palladio, I think the balance will be found in Vignola's favour, notwithstanding the opinion of so great a critic as Milizia, who places the great architects of the sixteenth century in the following gradation:—

"For knowledge and exquisite taste possessed by each in architecture, it appears that the first place would belong to Palladio! on his right hand would be Vignola, Buonarotti, Sansovino, and Vasari, and on the other Peruzzi, San Michele, Giulio Romano, and Serlio."

Vignola's Treatise upon Perspective was not published till after his death; his son Giacinto placed it in the hands of Ignazio Danti, a Dominican friar and mathematician of Bologna. Danti has well fulfilled his task of compilation, and has produced a work upon a subject, which was more carefully studied by the old Italian architects than by their successors. Both Vitruvius and Peruzzi, as well as Vignola, recommended its study as one of the means towards arriving at perfection in the art. The words of Vignola are "*La Scienza della prospettiva gli aveva aperto l'ingegno per l'arte di fabbricare,*" and I would here venture a remark to the students of the Institute upon the great importance of a sound knowledge of perspective for the proper study and practice of their profession. It would not be difficult to point out in several important buildings, instances of failure of architectural effect, arising from the designs having been merely studied geometrically.

Upon the principle so well laid down by Milizia, "That the best method of praising able artists is by making known their works," I will now proceed with a few remarks upon the executed works of Vignola at Rome, commencing with the little church of San Andrea a Ponte Molle, on the Via Flaminia.

The building was erected by Julius III., in commemoration of his escape on St. Andrew's day, 1527, from the German soldiery during the sack of Rome, and among the various inscriptions in the adjoining Villa Papa Giulio, Boissard gives the following as connected with this church. "In the neighbouring temple let thanks be given to God and St. Andrew, and let them (the visitors) pray for abundant health and eternal life to Julius III., Pontifex Maximus, to Baldwin his brother, and to their whole family.

This church is of a rectangular plan, of very moderate dimensions, and is chiefly remarkable for its resemblance in general exterior character to some of the small Roman temples. There is a great charm and beauty in the simplicity of the design, and the elegant details all bespeak the most careful study. Milizia, in his brusque way has some smart criticisms upon it, acknowledging at the same time that it was a work generally praised!

In the immediate vicinity of the Church of S. Andrea is situate the Villa Papa Giulio, commenced in 1550, by order of Julius III. I will not occupy the time of this meeting by a description of this building, with which, probably, nearly all present are familiar, either with the building itself or the charming illustrations of it by Percier and Fontaine. I cannot, however, resist the observation, that for the harmonious arrangement of the plan, for its style and character, for the refinement and delicacy of the enrichments, it is a model of suburban architecture. Ammanati in his fountains and ninfeo, and Zucchero in his beautiful paintings of the porticoes, have contributed much to its effect, but it is to the master-hand of Vignola, which guided and directed the whole, that we must award the palm!

My friend, Mr. James Morant Lockyer, who has with great credit given much attention to the study of numismatics, more particularly in reference to architectural representations upon medals, has kindly lent me a medal of Julius III., engraved both in Stern's and Letarouilly's works, upon which the Villa Papa Giulio is shown with two small cupolas surmounting the circular staircase and corresponding wing building. The effect in the medal is so successful, that I am induced to wish these lateral cupolas had been introduced in the building itself.

Near to the Villa Papa Giulio is the Vigna Giulia, and from their close vicinity and the resemblance in the names, the one building has sometimes been taken for the other in the works of Vasari and other authors. I am inclined to think the hand of Vignola may be traced on this latter building; it is an extremely picturesque composition and quite worthy of him. Letarouilly has treated this subject in his usual perfect manner, and he ascribes the design to Sansovino and Peruzzi. Giorgio Vasari states, that he himself was the first who designed it, adding rather indignantly, "that he was not one of those who made designs to please the capricious fancy of the pope, and which were afterwards obliged to be corrected by Michael Angelo and Vignola." From this passage it would almost appear, that Barozzi was really concerned in the design, but I have no doubt so careful an author as Letarouilly has good reasons for attributing the work to Sansovino and Peruzzi, and I am only doing justice to those two great architects in observing that the work in question is, at all events, worthy of Vignola. The Villa Lanti at Bagnaia, near to Viterbo, has also been ascribed to Vignola; it resembles his style, but it is not sufficiently refined and pure for that master.

At the Palazzo Farnese, Vignola executed that magnificent apartment so well known as the Caracci Gallery, with a portion of the Cortile, together with the decorations of several doors and windows, the most satisfactory details of which will be found in Letarouilly, who has also given as the works of Vignola, the lateral porticoes or loggie on the Capitol, the small Palazzo Spada in the Via di Capo di ferro, the Palazzo Nari, and a small palace at the extremity of the Piazza Navona. We have also the celebrated doorway of San Lorenzo in Damaso.

In reference to the entrance to the Farnese Gardens at Rome, I will again refer to the useful work on Doorways by Professor Donaldson, "It is useful, however, to consider whether this is an example to be entirely followed without reserve; certainly not;—but there are so few blemishes to remark, that it may appear almost unnecessary to notice them. It must be allowed, however. that the columns require being elevated above the level of the ground by a plinth. The rustications of the columns may be somewhat objected to as not sfficiently pure, but the harmony of the whole composition would have been destroyed had they been without; the attic is not sufficiently high, its proper proportions would have been to have equalled the entablature in height, this would have raised the plinth more above the cornice, and prevented its being intercepted by the projection of the latter. Some subsequent architect, with a taste as profane as it was daring, has introduced above this Capo d'Opera of Vignola, an attic, with caryatides, deteriorating materially its effect, and causing the deformity to be attributed to our great architect."

Now Milizia, who is generally not very sparing in his censure, is not quite so indignant as the writer whom I have just quoted, with respect to this "profane addition;" he merely says, "*Ma l'attico con quelle cariatidi è troppo grande,*" and upon referring to my own rough notes, I find that I was innocent enough to treat it as one design. Many, however, I dare say, will consider that the author of the work on Doorways has, in this instance, proved himself the best critic of the three, and that the addition must conseqently be condemned as—

> "A blot that will be still a blot, in spite
> Of all that grave apologists may write."

At the death of Michael Angelo in 1564, Vignola, in conjunction with Pirro Ligorio, was elected as his successor as architect to St. Peter's, with the strictest iujunctions from Pius IV. not in any way to alter the design made by Michael Angelo, Vignola's coadjutor, however, thought proper to disobey these commands, in consequence of which he was dismissed, and Vignola remained as sole architect, and he so continued for the space of nine years, up to the time of his death. The lateral cupolas are his, and are well worthy of his master-hand. Milizia's praise of them is as concise as it is expressive: "*Sono del Vignola e sono belle!*" I am inclined to the opinion, that no other part of St. Peter's was designed by Vignola, but that he merely put in execution the designs of his great predecessor.

Through the patronage of Cardinale Alexandro Farnese, Vignola was appointed architect to design the important Church of the Jesuits. This great work was commenced in 1568, its plan is that of a Latin cross, the length is 216 feet, and the width 115 feet. The building was only carried up as far as the cornice by Vignola, it was completed by Giacomo della Porta, or according to Milizia, "*Il resto fu esagerato da Giacomo della Porta.*"

The garden front of the Palazzo dei Fiorentini, in Campo Marzo, is attributed to Vignola; it is a graceful composition, and has lately formed the subject of a work by Cavalieri Folchi, a copy of which has been presented to the Institute by the author during the present session.

The two lateral loggie of the Capitol are attributed to Vignola by Letarouilly; they are of extreme grace and simplicity, and their effect considerably enhanced by the grand flights of steps upon which they rest.

The Porta del Popolo is also said to be by Vignola; it is not, however, a very first-rate production, and I am not particularly anxious to claim it for my favourite. Some contend that the front only towards the Via Flaminia is by Vignola, and that towards the city by Michael Angelo.

I am not aware that there are any other important works at Rome by Barozzi requiring notice. Mr. Donaldson has suggested that parts of the Villa d'Estè at Tivoli, particularly the central loggia of the front next the gardens, are by his hand, and I am inclined to the same opinion.

Of Vignola's works at Bologna, my friend Mr. Newman, who was there last year, has kindly lent me a sketch of the Loggia dei Banchi, a wing of San Petronio. Mr. Newman is of opinion, that the façade was altered only, and not altogether designed, by Vignola; the lower pilasters without bases, and the proportion of the arches, induce a belief that the upper part alone must be attributed to our great master. Mr. Newman has also kindly furnished me with a powerful sketch of the palace built for Achille Bocchi. This is a noble production, and a glorious example of Vignola's genius for the grand and sublime, as well as the refined and elegant. Its massive grandeur reminds us of the Florentine palaces.

Of the great church, Santa Maria degli Angeli, at Assisi, I regret I cannot speak from personal observation, but the difficulty has been obviated through the untiring kindness of our friend Donaldson, he having furnished me with a plan of the building taken by himself in the year 1818. The dimensions are immense; the extreme length inside the walls being no less than 347 feet, and the width 180 feet, but notwithstanding this colossal size, I am far from considering it, in point of architecture, as the greatest work of Vignola; the plan presenting no new or striking features, and effect appearing to have been produced by magnitude alone. The first stone was laid 25th March, 1569, only four years before Vignola's death, and Alessi and Giulio Danti are said to have had the superintendence of the building after Vignola's designs.

In the year 1832 this church was considerably damaged by an earthquake, but it has been since repaired, and at the present time, is not merely celebrated as the work of Vignola, but as containing a superb fresco, "The Vision of St. Francis," a *capo d'opera* by one of our own century, Overbeck!

Of the great Ducal palace at Placenza, I have no illustration. My friend Mr. Falkener informs me that it is by no means one of Vignola's finest productions. I will proceed therefore to bring before the notice of the meeting Barozzi's greatest work, Caprarola!

Near to Viterbo, and distant about twenty-six miles from Rome, stands this *capo d'opera* of Vignola. The situation on the sides of Monte Cimino is wild and romantic, commanding magnificent views on all sides, and presenting the most striking points as the spectator approaches. The bold and rugged site no doubt influenced the architect in giving that fortress-like character to his building, alike suitable to the situation and to the stormy and turbulent times in which it was built.

Vasari says that the original design for the fortress of Caprarola was by Antonio San Gallo, who had much practice in engineering and military architecture. I do not consider that this circumstance at all detracts from the merit of Vignola's subsequent share of the design, for it must have acquired as much (if not more) skill, to adapt his palace to San Gallo's foundations, as to have originated the palace-fortress itself.

The plan is pentagonal, with bastions at the angles, and while thus partaking of a military character, the architecture of the elevation is civil and palatial. Terrace surmounts terrace, the one communicating with the other by noble wide flights of steps. The basement is raised upon its sub-basement, excavated from the solid bed of rock, while two beautiful orders, towering proudly above these masses surmount the pile. Grandeur and sublimity reign without; beauty, grace, and harmony preside within. Well, indeed, might old Daniel Barbaro exclaim, when the first view burst upon him, "*La presenza è maggior della fama.*"

The arrangement of the plan is a masterpiece of skill; the circular court one of the most charming and harmonious compositions ever devised. The spiral staircase, with its ascending stories of columns and pilasters, perhaps unrivalled in the world; and while we gaze in admiration at the expanse of mind which conceived so great a work, our eye, as well as our imagination and taste, are more than satisfied with the exquisite refinement and purity of the details. Many years have now passed since I saw this grand specimen of Italian architecture; but I have a most vivid recollection of the strong feeling of admiration it produced on myself and fellow travellers.

Giorgio Vasari, in his 'Life of Taddeo Zucchero,' has given a minute account of this celebrated building, describing the various apartments with their superb embellishments by the brothers Zuccheri and by Tempesta, as well as several perspective views by Vignola's own hand.

In Le Bas and Debret's work upon the edifices of Vignola will be found the most architectural account of Caprarola. Some of the decorative paintings are given by De Prenner, in a fine work entitled 'Illustri Fatti Farnesiani;' and the plans and sections and elevations will be found also in Rossi's 'Studio d'Architettura Civile,' and in Percier and Fontaine's 'Maisons de Plaisance de Rome.' These celebrated French architects have also included the building in the grounds termed La Palazzina, the refined beauties of which are most elegantly and faithfully represented by them. The happy expression of Vasari with respect to the Villa Farnesiana at Rome, "*Non murato ma veramente nato,*" would in all respects apply to this Palazzina, one of the most exquisite creations of the refined taste and imagination of Vignola.

I have already made some mention of the part Vignola took in the designs for the Escurial; how far that gigantic royal convent has been erected according to the design furnished by our architect, it is difficult to say. The plan now exhibited belongs to Mr. Donaldson, who, following Milizia, attributes the design to Juan Battista di Toledo. It appears that the palatial bears but a small proportion to the ecclesiastical part of the edifice, which, as a whole, has not been unhappily described by Beckford as being "at once a temple, a palace, a convent, and a tomb."

Vignola has not merely instructed us by his executed works, but he has left a guide for all time in his admirable treatise upon our art. To him we are indebted for rules, proportions, and maxims, the result of a careful study of the architectural remains of ancient Rome; and, although this great master has founded his orders upon the antique models, he was no servile copyist or imitator, but proved himself as eminently successful in his original productions as he was in his adaptation of the remains of antiquity. His beautiful and original introduction of consoles connecting with the modillions in a crowning cornice has been frequently imitated in continental buildings, and in our own country by Wren, at St. Paul's, as well as by many other of our principal architects of the past and present day; his playful adaptation of ornaments over his doors and windows, and his ingenious and bold application of rustics, afford us examples of originality well deserving our attention and study.

In some valuable remarks on the genius of this great artist, I entirely concur with Mr. Cockerell, who has observed that "Vignola was sparing in the use of the orders, not lavishly employing them in a vulgar and common manner, but applying them rather as precious decorations to be tenderly and delicately treated; he relied much upon his door and window dressings, making his window openings extremely small, thus giving great breadth and scale to his façades. The introduction and treatment of rustics in his portones is most masterly, frequently uniting them with the stringcourse of the *piano nobile*. For his door and window dressings he stands unrivalled."

It is too much the fashion of the day to underrate the value of the study of Classic architecture and its revival under the great

Italian masters; some are for an extensive and nearly exclusive application of Mediæval architecture, while others are for forming a national style of our own, which should have the merit of "being something new." The acute and strong-minded Forsyth remarks upon this point, "I do not indeed admire the philosophy which has lately broken into architecture, nor the contempt so often affected for Vitruvius. I would not subvert the authority of example, nor be too severe upon the ancient superstitions of the art. Their very antiquity, if it does not satisfy our reason, has a charm on the fancy, and they fill up a space which our reverence for what is old would make it difficult for a reformer to fill up more pleasingly." And with equal force has it been observed by that most eloquent instructor of art, Sir Joshua Reynolds, "Invention is one of the greatest marks of genius; but if we consult experience, we shall find that it is by being conversant with the invention of others that we learn to invent, as by reading the thoughts of others we learn to think."

In these days we have every possible facility and inducement held out to us for the attainment of a thorough knowledge of our art. Upon the opening evening of our present Session, the Gothic architecture of Germany was graphically described and analysed by one of the first scholars of our times, the Master of Trinity College, Cambridge. Our Professor's chairs are filled by the most able instructors. We have excellent weekly and monthly publications affording us both scientific and practical information. Our museums are daily being enriched with sculptured remains from the most ancient cities in the world. We have societies devoting their time and energies to the publication of architectural stores which have hitherto been confined to the few, and nearly unknown. The wonderful architecture of Southern India has been brought to our view and described and commented upon in this room with the most profound learning: while the Oxford graduate steps forward with all the advantages of sound scholarship, intellectual mind, and poetical imagination, to enlighten us with his 'Seven Lamps of Architecture.'

My own impression is, that each different style has its distinct and separate beauties and features, and it is not by a blind adherence to one particular school for all purposes, but by a proper adaptation of the style we may select for the object to be attained, that we can command success.

I would not for one moment be supposed to detract in the slightest degree from the great merit of many of our rising architects in the admirable designs and structures they produce in imitation of the ecclesiastical and domestic architecture of our forefathers, and the experience of the last ten years has proved to us that their success progresses with their knowledge and research. A similar persevering study of Italian examples would no doubt produce similar satisfactory results; and as the broach spire and the porch of the thirteenth century may not possibly be found suitable for every street or square in the metropolis, or in our provincial cities and towns, I should rejoice to see the studies of our young architects also directed to the spires of our own immortal Wren, to the cupolas of Brunelleschi and Michael Angelo, and to the works of my favourite Giacomo Barozzi da Vignola.

N.B. On referring to the several illustrations, Mr. Angell took occasion to acknowledge the obligation he was under to his brother Members, Mr. John Davies, Mr. Charles Parish, Mr. Edward Falkener, Mr. W. W. Deane, and Mr. H. Oliver; as also to Mr. James Morant Lockyer, Mr. F. B. Newman, Mr. E. Pritchard, Mr. Arthur Hakewell, and to his own pupils, Mr. George Judge, jun., and Mr. Henry Wood, for the valuable drawings, sketches, and many points of interesting information they had afforded him. Mr. Angell also took occasion to refer to a plan of Caprarola, belonging to Mr. Hardwick, made in 1778, by Mr. Thomas Hardwick, his late father, and Mr. Angell's most esteemed master and worthy instructor.

List of Popes during the Lifetime of Vignola, A.D. 1507 *to* 1573.

A.D.	Name.	Contemporary.	
1503	Pius III.	Henry VIII. of England, 1509.	
"	Julius II.	"	"
1513	Leo X.	"	"
1522	Adrian VI.	"	"
1523	Clement VII.	"	"
1534	Paul III.	"	"
1550	Julius III.	Edward VI., 1547.	
1555	Marcellus II.	"	
"	Paul IV.	"	
1559	Pius IV.	Mary, 1558.	
1566	Pius V.	Elizabeth.	
1572	Gregory XIII.	"	

Remarks made at the Meeting after the reading of the foregoing Paper.

Mr. ANGELL on concluding his paper, having been greeted with considerable applause,

Mr. TITE said he was desirous of putting language into those cheers, and therefore he would move a vote of thanks to Mr. Angell for his interesting and successful paper, which was equally complete as a memoir of Vignola, and as an illustration of his works. He had tried to find out if there were any circumstances relative to Vignola which were not generally known, and he had discovered, as well as Mr. Angell, that Vasari was jealous of Vigoola, for he found very little about him under the head Barozzi, and under that of Vignola nothing at all. The great bulk of the information respecting Vignola in Vasari was given incidentally, and he broke off rather abruptly, saying he should say more about it in another place, but that other place was nowhere to be discovered. The struggles of Vignola to attain a position were as remarkable as the eminence which he succeeded in achieving. The gradual and laborious steps by which he rose to eminence, and his ultimate success and distinguished position, afford to young architects many an useful lesson of perseverance and hopefulness. Mr. Angell had early in life discovered the excellencies of his favourite, and he hoped that now later in life he would give the Institute a little more of the Italian architects of the 16th century. He agreed with his friend that this architecture, as applicable to ecclesiastical purposes, had of late been too much neglected. There was, he admitted a great deal of beauty and fitness of purpose in mediæval architecture, but admiration for that style might be carried too far. It might be considered an heretical opinion, but he believed that a church might be built for Protestant worship much better adapted for the purpose than many of the structures recently erected, beautiful although they undoubtedly were. He would say, let the latter be built, but do not let the Italian style be cast aside. He knew that fashion possessed imperative influences, and that to live the architect must in some degree obey the taste of the times; but he honestly thought that the neglect of the Italian for the mediæval, if carried much further, would be a serious evil. Even now English architects had not progressed in their ecclesiastical buildings as they ought to have done. He hoped the elaborate and elegant essay they had just heard would revive in the minds of those present,—and he knew how much influence they exercised over the general taste of the community,—the study of Vignola. His object in rising was, however, to move that the ordinary compliment, offered in no ordinary sense, be given to his friend, as well as their sincere thanks for having delivered so elegant, so complete, and so useful a paper.

Mr. HARDWICK could not allow any other person to second the motion, for he had had the good fortune to be brought up in the same office with Mr. Angell. They had pursued their studies together, and when he saw the application, the zeal, the attention which his friend exhibited, he felt confident that sooner or later he would show great talent in his art. The paper that had just been read showed that he was perfectly right in his anticipations; for a more exquisite, a more charming essay on Italian architecture had never been written. He had visited many years ago the Caprarola of Vignola, in his opinion one of the most beautiful specimens of art in existence. He entirely concurred in the hope that this paper would bring back their students to a greater attention to the architecture of Italy. The architecture of the middle ages was beautiful and picturesque, and in many instances reached sublimity; but at the same time, some attention to the fine architectural taste and genius exhibited in the works of Vignola, and other Italian architects were essential to the student. He hoped every student present would allow the paper to make a due impression upon his mind, and that all of them would study the works of the Italian architects a little more than was now the practice.

The CHAIRMAN thought that young English architects would derive as much advantage from the study of Bramante and Vignola, as English painters derived from the examination of the great works of Michael Angelo and Titian. There was one expression which fell from Mr. Angell in his paper, in reference to which he wished to say a word or two. Mr. Angell spoke of the Italian style, a phrase perfectly justifiable by common parlance, but in his opinion extremely incorrect. The style of architecture in Italy was that which had prevailed ever since architecture had been civilised by Greece, greatly modified no doubt by political changes and social circumstances, and altered by the necessities of the times, and by the extended scope of the science of construction. Still it was essentially the same style; and it might be regarded (to take the mode of expression used in natural history), as a species belonging to a genus, which comprised Greek, Roman, Italian, and Modern architecture.

Mr. COCKERELL could not make up his mind to give a silent vote, although he would not repeat the compliments so due to Mr. Angell, which had been expressed by those, who had spoken for the whole sense of the Society. He joined in all those expressions of gratification, and also in the hopes which had been expressed for the revivification of the old masters, dug out from the remains of Italian architects as it were by this admirable paper, descriptive of one of those masters, not the least remarkable, interesting, and conspicuous in his career. He sincerely hoped that the works of the other great Italian architects of the 16th century would be presented to them in a similar manner; and by a comparative study of these "great lamps" of architecture, they should be able to appreciate the peculiar secrets and motives of progress which the art had made from Bramante, with his minute, silvery, delicate modes of building, down to the peculiarly symmetrical structural idiom of Raffaelle. They would then be able to see how from one master to another what immense progress was made, and wherein was the secret by which the peculiar beauties of each were achieved. They saw by the admirable history which had just been read, how Vignola became an architect from being a painter; how he was a master of perspective because he was a modeller. Being a painter, he could amalgamate things which had not hitherto been incorporated, and thus be achieved a wonderful degree of progress in his architecture. He would remark casually as an instance of what he meant, that Vignola was the first to effect a combination between the arch and the column, and be united them in a manner altogether original, incorporating the keystone of the arch with the pilaster, so as to form one and the same structure. They all as good architects took care that it was so in fact; but they must admit the high merit of the man, who first made such a junction one of the beauties of architectural decoration. With regard to the great end of all proportion—magnitude—he apprehended Vignola attained that excellence by very extraordinary means. It was done simply by the smallness of his apertures. Indeed, the real magnitude was not nearly so surprising as its apparent dimensions, and thus they had here revealed one of the great secrets of architecture, how by the contrivance of proportions great magnitude might be obtained. The effects of the study of Vignola upon French architecture was apparent; the French confessed him to be their architectural saint, just as Palladio was our saint; and they had as great a number of beautiful translations of Vignola as we had of Palladio.

The vote of thanks was then passed by acclamation.

METEOROLOGY.

Sir—Your readers will agree with me that an importance, hardly to be estimated, attaches to the laws regulating the atmosphere which supplies us with the means of existence, surrounds us at all times, permeates our frame, and which conveys on wings unseen disease and death. Yet how few direct attention to the study of the phenomena of meteorology. Through the energetic exertions of James Glaisher, Esq., F.R.S., of the Royal Observatory, returns of observations, more or less elaborate, are obtained from between 30 and 40 stations in Great Britain. Observers remark, for the most part three times in 24 hours, the state of the barometer—the thermometer—the clouds and the wind, and register the quantity of rain daily. Mr. Glaisher receives by the electric telegraph the state of the atmosphere, and the direction of the wind, from various stations along the principal lines of railway at 9 a.m. daily; and from these data I have no doubt but that, in time, some valuable laws will be deduced in addition to those which he has already established.

I am anxious that scientific men should direct their attention to the subject of meteorology; and that amateurs who have time at their disposal should record observations in their own localities. If I thought it would interest your readers, I should be happy to describe such instruments as are adapted to the purpose; for, unless these are good and worthy of reliance, the time of the observer will be wasted and his observations useless.

I subjoin a table of certain meteorological results, from observations taken in various parts of England: the comparison of these will not, I apprehend, be without interest.

I am, &c.

John Drew.

Southampton, Feb. 14th, 1850.

Synoptical View of the Meteorology of various places in England, for 1849.

(Deduced from the Registrar-General's Reports.)

	Mean Pressure of dry Air, reduced to the Level of the Sea.	Mean Temperature.	Temperature of the Dew-Point.	Number of Days on on which Rain Fell.	Amount Collected.	Degree of Humidity, complete Saturation being 1.
Guernsey ..	29·750	52·3	45·5	167	36·5	·812
Falmouth ..	——	51·3	—	168	44·5	—
Exeter......	29·742	50·2	41·7	151	26·1	·808
Greenwich ..	29·692	49·8	43·2	153	23·8	·802
Aylesbury ..	29·622	49·2	42·3	157	27·	·791
Southampton	29·6 0	50·6	46·7	139	33·	·816
Derby	29·732	47·4	42·8	193	28·5	·837
Liverpool....	29·670	49	41·9	—	30·5	·827
Stonyhurst ..	29·686	46·2	41·5	216	49·2	·850
Newcastle ..	29·613	47·1	42·7	146	36·4	837

[We shall feel obliged if Mr. Drew will favour us with a description of such instruments as are adapted for the purpose, and we shall be happy to make our *Journal* the medium of such observations as Mr. Drew suggests.]

REPORT OF THE COMMISSIONERS
APPOINTED
TO INQUIRE INTO THE APPLICATION OF IRON TO RAILWAY STRUCTURES.

The Commissioners of Railways showed a vigilant anxiety for public safety and for the advancement of science, and greatly promoted both, when in August, 1847, they obtained the appointment of a Commission "for the purpose of inquiring into the conditions to be observed by Engineers in the application of Iron in Structures exposed to violent concussions and vibration."

The result of the labours of this Commission are now before us; and it is not too much to affirm that the present Report is almost, if not altogether, the most valuable public document extant relating to the science of engineering. For some time past the note of preparation for this work has been heard: we have had accounts of cabinet ministers being attracted by the magnitude and importance of the experiments, to examine them. More recently, Professor Willis has delighted a learned audience at Cambridge by the facility and simplicity with which he contrived to explain the most difficult subject on which he has been engaged as a member of the Commission; and the memoirs read by Professor Stokes, before the same academic body, have shown that the highest powers of mathematical analysis have been brought to operate upon and generalise results of experiments—to analyse and classify them—to group facts which were barren while isolated—to expand them, and give them the vitality—so to speak—of general principles.

The right method of pursuing investigations of this kind is this combination of theory and fact. The "practical man" is afraid of theory, and demands that all the rules for his guidance shall be deduced immediately from precedent alone. To this demand the simple reply is, that—desirable as it might be to comply with it—compliance is impossible. The requirements of actual railway construction are many and various—the means of experimenting few and restricted; so that, setting aside the question of expense, it would obviously be impracticable, in a reasonable duration of time, to furnish from observation a code of direct precedents for all the purposes of the engineer.

On the other hand, where experiments are undertaken for the judicious purpose of aiding theory, they should be carried out on such a scale as to leave no suspicion that they are mere toy-experiments—amusing illustrations of science made easy; and with this reflection, we cannot but observe with regret, that in several places in the work before us apologies are made on account of the limited means at the disposal of the Commission. From the importance of the inquiry, and the gravity of the events in which it originated, the public had a right to demand that the researches should not be impeded by ill-timed parsimony. Compare the scale of experiments on Railway Bridges with those on Government Ship-building! or, to make a more direct comparison—contrast the scale of the government experiments on Girders witb those relating to the Tubular Bridges! It would be curious to calculate how many times the weight of metal in the magnificent model-tube experimented upon by Mr. Fairbairn at Millwall exceeded that of all the iron together employed in the researches of the Commission.

One advantage has, however, sprung from the restrictions complained of: they have served to show the immeasurable value of accurate scientific knowledge, and its power of extracting truth under difficult circumstances. The edict had gone forth: there must be no expenditure of public money on large castings of iron—*fiat experimentum in corpore vili*. But, notwithstanding, the Commission have succeeded in producing a body of sound invaluable information, as copious and accurate as was expected at their hands by those who anticipated that every facility would be afforded to them in the prosecution of their task. Unlearned investigators are apt to deduce from restricted experiments rules which will not bear the test of extended observation. In the present case, the happy combination of science and experimental skill displayed by Professors Willis and Stokes has averted this danger. However, it is important not only to deserve confidence, but to readily obtain it; and it is, therefore, much to be regretted that, if merely to satisfy the scruples of those who can only take facts just as they find them, more experiments on a large scale were not undertaken.

The Report and accompanying documents are comprised in a thick folio volume, of the well known blue-book form: a second volume consists of plans and plates. The Report itself extends over comparatively few pages. The other papers are principally as follows:—Appendix A. Experiments on Impact upon Beams, and on the tensile, compressive and transverse strength of Iron; Appendix AA. Inquiries to supply data for the erection of the Tubular Bridges; Appendix B. An Essay by Professor WILLIS, on the deflection of Beams by travelling loads, with researches by Professor STOKES; Experiments on the same subject, by Captain JAMES and Lieut. GALTON; also on statical pressure and slowly-moving weights; Evidence by eminent engineers; Replies to circulars sent to Iron-masters and Iron-founders; &c.

The plates in the second volume are illustrative of the several kinds of experiments, and include elevations and details of a very considerable number of important railway bridges.

The Report commences with a notice of the contrariety of opinions respecting the effects of travelling weights on girders—some engineers thinking one-third, and some no more than one-tenth the statical breaking weight, the greatest load which the structures could safely bear. It is stated, that in the course of the inquiry, it appeared "that the effects of heavy bodies moving with great velocity upon structures had never been made the subject of direct scientific investigation." This may be true as regards publication before the *commencement* of the inquiry by the Commission; but very shortly afterwards, and long before the publication of the present volumes, the paper (which is noticed in it at page 213, by Professors Willis and Stokes, with approbation) "on the Dynamical Deflection and Strain of Railway Girders," appeared in the number of this *Journal* for September, 1848.

In the experiments of the Commission, velocity had considerable effect in increasing deflection. It is, however, important to know that the conclusion is not extended to practice. The results of the inquiry thoroughly confirm the conclusion stated in this *Journal*, that in real railway girders the deflection is *inconsiderably increased by the velocity of the transit of a train.* The reason that the experiments apparently vitiate this conclusion is admirably elucidated by Professors Willis and Stokes. For the present, it is sufficient to observe that the increase of deflection in the experiments arose from the smallness of the mass of the beams compared with that of their loads.

An apparent inaccuracy as to the history of the Laws of Elasticity occurs in Appendix A, given in another part of this *Journal** :—

"Dr. Hooke's law, expressed by him in the phrase '*ut tensio sic vis*,' is not, perhaps, accurately true in any material. Its deviation from truth in cast-iron, under every degree of strain, even the smallest, was first shown by experiments made by the author, and reported in the sixth volume of the *Transactions* of the British Association for the Advancement of Science. In his subsequent researches on the elasticity of various materials, it was shown that this defect was considerable in stone and other crystalline bodies tried, and existed in a less degree in wrought-iron, steel, timber, and laminated substances."

The inexactness of "Hooke's law" was shown about 100 years before any member of the Commission was born, and by no less a person than James Bernouilli. In the *Acta Eruditorum* of Leipsic, for 1694, he gives investigations of the elastic curve—1, generally when the elastic forces follow any law whatever; 2, when they vary as any power of the extension; 3, when they are directly proportional to the extension. The latter investigation he prefaces by saying†—

"The common hypothesis, as I have just said, is, that *the extensions are proportional to the stretching forces*, which was formerly adopted by the celebrated Leibnitz, in his most ingenious research respecting the *Resistance of Solids*; and by myself in the present subject, before that I arrived at the general construction of the problem. I therefore consider it worth while to explain a little more particularly the nature and properties of our Curve on this hypothesis; although I am very unwilling to contend for the precise truth of this hypothesis, or of any other, being persuaded, rather, that no constant law of tensions is observed in nature but that it differs according to the different texture of bodies. This is seen to be abundantly confirmed, both by my own and other persons' experiments, of which a great part are industriously collected by the author, whom I have already commended [Franciscus Tertius de Lanis] in the above quoted treatise, *Magisterii naturæ et artis.*"

There seems no reason to suppose that an exact mathematical law of elastic tension can exist, or that a law which expresses the extension by the first, or first and second, powers of the tension, can be otherwise than approximate. With respect to many forces existing in nature, there can be no such antecedent objection to an exact mathematical law. For central forces, such as the sun's attraction, we may readily suppose *a priori* that the law may be that of the inverse square, because if the attraction be supposed to radiate into space, like light, the concentric spherical surfaces over which it is diffused vary in magnitude as the square of their radii. But with regard to the cohesive force of particles in contact, there can be no such regularity of operation. The tensile powers of a piece of stone or iron are affected by its heterogeneity, crystallisation, lamination, porosity, chemical affinities, temperature, &c. Now, in discovering a law of tension from experiment, all these irregularities are "lumped" together, and we strike an average of their effects.

If, as in some of the experiments before us, twenty different weights be applied to stretch in different degrees the same rod, a theoretical law involving first and second powers only, will slightly disagree with each of the twenty experimental results. We must, therefore, suppose either the law or the experiments, or both, to be inexact. If the experiments exhibited perfect accuracy (though this is never attainable), the law must not stop at the second power, but be continued to the twentieth; for there will be twenty equations to determine twenty unknown quantities—namely, the co-efficients of the twenty powers. A formula involving the first four powers is given in a note, page 113.

We observe with pleasure a notice of the efficient assistance which Mr. Tredgold, son of the late celebrated writer of the 'Treatise on the Steam-Engine,' rendered in the course of this experimental inquiry. In addition to a great amount of numerical computation and experimental observation, he prepared several excellent drawings illustrative of the experiments, and appearing with his name in the second volume.

It will be remembered, that some surprise was occasioned by the publication in the recent edition of Dr. Gregory's 'Mechanics for Practical Men,' of the results of some experiments giving higher values for the tensile strength of cast-iron than have been hitherto generally adopted. This subject has been again referred to careful observation; and an explanation, which seems correct, is given of the too high values of the tensile strength obtained by Mr. Thomas Cubitt—namely, that he used a hydraulic press to test the iron, and that this machine is apt to give exaggerated results. Experiments have also been made, to determine whether the tensile strength be greater for cruciform than for circular or rectangular sections of the rod. It appears that the strength per square inch of section is a little (but only a little) stronger for the cruciform section, the excess of strength being attributed to the metal being harder in the thinner sections than others. We may here remark, that for a similar reason the strength per square inch, of circular sections for example, is probably somewhat affected by the magnitude of the section. On account of irregularities of casting and cooling, it is probable that a circular rod 4 square inches in area, would not be exactly twice as strong as a similar rod of 2 square inches area.

Only one beam exceeding 15 feet in length appears to have been used; and this was supplied not by government, but by private persons. It was 48 feet long; and one of several girders intended for a bridge across the river Irwell. Lieutenant Galton, the indefatigable secretary of the Commission, assisted at this experiment.

In order to notice all the statical experiments together, we proceed to refer to experiments by transverse pressure on rectangular beams, made by Captain James at Portsmouth. The most remarkable of these experiments were on ¾-inch bars *planed out of the centres of 2-inch square and 3-inch square bars.*

These experiments, like the preceding, show that the deflection increases from the commencement of each experiment somewhat more rapidly than in proportion to the transverse pressure. Experiments were also made by means of the hydraulic press on the effect of tension bars attached along the under sides of the bottom flange of cast-iron girders. The mean of several experiments on girders 9 feet between the supports, gave the breaking weight with the tension bar rather greater than without it; and similar results were obtained from girders with the upper flange arched. These experiments were not, however, followed out (from "want of time and *limited means*" again!) so far as was deemed desirable.

Our notice of other parts of the inquiry we reserve for future consideration.

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† See Journal, page 80.

* Vulgaris (ut modo dixi) est hypothesis extensiones viribus tendentibus proportionales esse: qua et usus olim celeberrimus Dr. Leibnitius in acutissima sua lucubratione de Resistentia Solidorum; et ipsemet ego in præsente materia, prius quam generalem problematis constructionem advenissem. Quapropter operæ pretium existimo, naturam et proprietates curvæ nostræ in hac hypothesi paulo specialius exponere: quanquam pro ipsa hypotheseos hujus, sicut et pro cujusvis alterius, veritate multum militare nolim, persuasum potius habens, nullam constantem tensionum legem in natura observari, sed eam pro diversa corporum textura diversam existere. Id quod experimenta tum nostra, tum aliorum, abunde confirmare videntur, quorum plurima prælaudatus Author industrius "*Magisterii naturæ et artis*" loco cit recenset.—p. 270-1.

APPENDIX (A) TO REPORT ON IRON.

By Eaton Hodgkinson, Esq. F.R.S.

The following series of experiments was conducted by the author, partly in London, and partly in Manchester. The description and tabular results of the whole are given in this Appendix, with such general conclusions from them, as the limited period of the time of preparing the results for the press permitted.

In accordance with the instructions under which the Commissioners acted, the experiments were directed principally (though not wholly) to determine the effects of impacts and vibrations upon iron. Several distinct classes of experiments have therefore been undertaken, for the purpose of exhibiting the properties of cast-iron, in particular, when subjected to different mechanical tests, and the numerous tables appended will show the extent and variety of these inquiries.

An extensive experimental inquiry, not yet published,* had been recently concluded by the author, of which the object was to determine the mechanical conditions to be observed, in the construction of the tubular bridges across the Menai Straits and the Conway.

Among other results, it was ascertained that a great saving of metal for an assigned degree of strength might be effected by employing cast-iron longitudinal ribs in the top of wrought-iron tubes. It seemed, therefore, very desirable to ascertain for the purpose of this Commission, whether, and in what manner, the combination of wrought and cast-iron might be advantageous in trussed girder bridges. For such experiments, peculiar facilities existed, as they might have been made with apparatus of a very complete and costly description, which had been constructed for former experiments on the strength of materials, and much extended for those on tubular bridges.

Of the latter, some of the models experimented upon were large, and varied in weight from three to seven tons. Had experiments on trussed girders of half that weight at least, been made, it is probable that valuable conclusions, directly applicable to the practice of engineering, might have been obtained. The expense attendant on such experiments would, however, have been great, and the limited extent of the grant to the Commission, rendered it necessary to confine the inquiries to those subjects on which a knowledge of fundamental principles was most required. It became then a matter of careful consideration to devise the experiments in such a manner that their practical utility might be as little as possible affected by the restriction referred to, as the scale of the experiments did not always permit direct and immediate comparison, with the actual practice of railway construction.

The experiments were therefore conducted, so as to obtain principally those scientific data, which appear to be most required for completing the mechanical theory of elastic beams.

Defect of Elasticity.

In any general investigation of the properties of elastic beams, the powers of the material to resist direct tension and compression are necessary data. If a beam be in any manner bent, its concave side will be compressed, and its convex side extended. The material is, consequently, subjected to both tensile and compressive forces; of which, therefore, an exact knowledge must precede any accurate general theory of the laws of deflection, vibration, and rupture.

The longitudinal compression and extension of iron within certain limits are usually assumed to be directly proportional to the external forces by which they are respectively produced. The law is known by the name of Doctor Hooke, the first proposer of it, and has generally been made the basis of mathematical investigations respecting the deflection and strength of loaded beams.

Doctor Hooke's law, expressed by him in the phrase "*ut tensio sic vis*," is not, perhaps, accurately true in any material. Its deviation from truth in cast-iron, under every degree of strain, even the smallest, was first shown by experiments made by the author, and reported in the sixth volume of the *Transactions* of the British Association for the Advancement of Science. In his subsequent researches on the elasticity of various materials, it was shown that this defect was considerable in stone, and other crystalline bodies tried; and existed in a less degree in wrought-iron, steel, timber, and laminated substances.

It is a necessary consequence of the ordinary law of elasticity that the deflection of a horizontal beam by a vertical pressure should be directly proportional to that pressure. This conclusion, as might be expected, does not, however, coincide with experiments on beams of those materials, of which the elasticity has been above stated to differ considerably from that assigned by Doctor Hooke's law.

As the law of elasticity constitutes the very basis of all sound knowledge of the statical and dynamical properties of girders, the revision of that law, with respect to cast-iron at least, became, in the author's opinion, an indispensable requisite in the present inquiry. He, therefore, obtained liberty to make some experiments on the extension and compression of rods of iron, in order to deduce from them, if possible, the general relations between the weights and the changes of length produced.

To numerous experiments respecting impacts, occupying 27 tables, and to others made to determine the direct tensile and crushing strength of irons, not previously tried—besides some of smaller magnitude—the following experiments are added:—

1st. To determine with precision the direct longitudinal extensions and compressions of long bars of cast and wrought-iron, by weights varied by equal increments, up to that producing, or nearly producing fracture.

2nd. To seek for general formulæ, connecting the weights with the corresponding longitudinal tensions and compressions of cast-iron, and likewise, if practicable, with the "sets," or permanent alterations of the length of the rods remaining after the removal of the external forces: in order that the former may be directly applied to the determination of the situation of the neutral line, and the strength of cast-iron beams of every form of section.

3rd. To determine with equal precision, the deflection of horizontal bars produced by various transverse pressures, and to compare the effects with those produced by impacts.

4th. To seek for general formulæ connecting the transverse pressure, the deflection, and the set remaining after the pressure was removed.

The great defect of elasticity of cast-iron, and particularly as compared with that of wrought, may be rendered very obvious by the results of the experiments on each of the irons, with respect to extension, compression, and transverse flexure.

The theories in common use, at the present time, proceed on the supposition, that bodies strained are perfectly elastic; and therefore the extensions, compressions, and transverse flexures are assumed to be, within certain limits, as the forces producing them. Thus, $w =$ the weight applied to stretch a body, and $e =$ the extension produced by that weight, the ratio $\frac{w}{e}$ ought to be constant with different weights laid on the same bar, and it will be found much more nearly so in wrought-iron, than in cast, but in neither strictly so. If, in like manner, w^1 be the weight applied to compress a bar, and d the decrement of length it has sustained, $\frac{w^1}{d}$ ought to be constant, but there will be a falling off, analogous to the last, in cast-iron particularly. In the transverse flexures of bars, if w_1 represent the weight laid on, and d the deflection produced, $\frac{w_1}{d_1}$ ought to be constant, but the falling off will be as in the preceding cases.

Formulæ for the Resistance of Bars to Horizontal Impact.

In an experimental inquiry by the author, into the power of beams to sustain impact from a body striking them horizontally, or falling directly upon them, it was shown that if blows of the same magnitude were given upon the middle of a beam, either by elastic or inelastic bodies of the same weight, the same effect would be produced. The striking body appears to proceed with the beam after impact, as if they were one mass.—(5th Report of the British Association, 1835.)

In the inquiry above, formulæ were deduced according to these conclusions, both for horizontal and vertical impacts, taking into consideration the effect of the weight or inertia of the body struck.

Formulæ for horizontal impacts are comparatively simple, and that given below is the same as that of Tredgold.—(Essay on the Strength of Iron, Art. 302.)

$$\frac{h w^2}{w + w'} = \frac{p e}{2}$$

where $w =$ the weight of the striking body, $h =$ the height due to the velocity of the impact, $p =$ a pressure which applied gradually to the middle of the beam, would bend it to an extent equal to that produced by the impact $e =$ the deflection caused by that pres-

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* The work here mentioned appears in the Report, under the designation of Appendix AA.

sure, and $w' =$ a weight equivalent to the resistance of the beam, from its inertia.

If the resistance of the body struck had been uniform, the right side of the equation would have been twice as great, or $p\,e$; but in a beam, the resistance to flexure is nothing in the commencement, and it increases in proportion to the flexure.

The preceding formula gives the impact, in terms of the height fallen through by the ball or striking body; but, in the experiments, the deflections are given in terms of the chord of the arc of impact, and the following formula would represent them.

$$d = w c \sqrt{\frac{e}{p' r (w + w')}}$$

where $d =$ the deflection of the beam, $c =$ the chord of the arc, $r =$ the radius, from the point of suspension to the centre of the ball, $p' =$ any pressure applied to bend the beam, $e' =$ the deflection caused by that pressure, and the rest as before.

The value of w' depends upon the weight of the beam, and as a mean, it may be taken at one half of the weight of the beam between the supports, as was shown by the experiments in the Report above-mentioned.

Objects of the Tables of Experiments, with some of the Results arrived at.

Tensile and Crushing Strength of Cast-Iron.—Tables I. to V. These experiments were made to ascertain the direct tensile and crushing strengths of several denominations of cast-iron in common use, but of which these properties had not been at all determined, or very imperfectly. The irons of which the tensile force was determined, were 17, and the crushing force of all these irons was also obtained.—(See Abstract, No. I.)

Tranverse Pressure on Bars, very long and flexible.—Tables I. to VI. contain results on the *transverse strength* and resistance of very thin flexible bars, by forces acting horizontally, the ends of the bars being supported on friction rollers. The experiments were made to exhibit very fully the deflections and sets of cast-iron, and the defect of its elasticity; in order to throw light on the great deviations in this metal, from computations according to the theories in common use; and to explain anomalies in some of the results of the other parts of this inquiry. Thus, by showing that *defect of elasticity*, the cause of these anomalies, *was nearly as the square of the deflection*, it was rendered probable that the value of the weight might be expressed in terms of the difference between the 1st and 2nd powers of the deflection, instead of the 1st power alone, on which it had been assumed by previous authors to depend. This being tried, was found to give results differing but little from those of the experiments, as may be seen by turning to the tables. Formulæ for the weights and sets, in terms of deflections, were obtained.

Long-continued Impact upon Bars of Cast-Iron.—Tables I to IV. are on the effects of *long-continued impact*, applied horizontally, upon the middle of the beams, to ascertain to what degree beams or beam bridges might be successively deflected, by impacts and vibrations, to resist fracture for any length of time. As an abstract of the results of these experiments is given, they will not be further noticed here, except to mention that *it is scarcely safe to bend beams constantly to one-third of their ultimate deflection, and that they ought not to be loaded to more than one-sixth of their breaking weight laid on rapidly.*—(See Abstract, No. II.)

Horizontal Impact upon Bars of Cast-Iron.—Tables I. to III. show that bars of various forms of section, but of equal weight, offer the same resistance to impact when struck by the same ball. Thus a bar 6 × 1½ inches in section, placed on supports 13 feet 6 inches asunder, required the same magnitude of blows to break it in the middle, whether it was struck on the broad side or the narrow one; and these blows were required to break a bar, the section of which was 3 × 3 and the length the same. The main object of these experiment was to furnish data for a correct theory of the resisting power of bars to impact.—(See Abstract, No. III.)

Impact on Bars of Wrought-Iron.—Another course of experiments was tried, to ascertain the effects of horizontal impacts upon bars of wrought-iron, to compare together the results from pressure and impact, and to obtain the resistance of the bar from its own weight.

In these the deflections produced by a ball suspended with a constant radius, were nearly as the chord of the arc through which it was allowed to fall, to strike the beam at the bottom of the arc. In other words *the deflection of the beam was nearly as the velocity of impact*, since the velocity varies as the arc. The deflection in cast-iron bars is greater than in proportion to the velocity.

Vertical Impact on Loaded Bars.—On the effect of vertical impacts on loaded bars of cast-iron.

These experiments show, that beams loaded to a certain degree, with weights attached to them, and spread over their whole length, so as not to prevent the flexure of the beam, resisted greater impacts from the same body falling on them, than when the beams were unloaded, in the ratio of 2 to 1. For other particulars, and a property connecting the velocities of impact and deflections, see Abstract, No. IV.

On the Extension of Cast-Iron Bars.—The experiments of this class were made on bars one inch area of section nearly, and 50 feet long. They were suspended vertically from the top of a high building, and had weights attached to the bottom; the weights were varied by small increments, until the bar broke; the extension and set, with every change of weight, were obtained with great care. The results being afterwards reduced to what they would have been, if the length had been 10 feet, and the area of a section 1 square inch.

From these, formulæ were obtained connecting the weights with the extensions.

On the Compression of Cast-Iron Bars.—Tables I. to VI. contain results of experiments on the compressions of bars of the same irons, 10 feet long and 1 inch square; together with formulæ connecting the weights and the compressions produced by them.

The results, both of extension and compression of cast-iron, have been adapted to any length l at pleasure, in order that they might be applied to determining the transverse strength of a beam of cast-iron, on more correct principles than those hitherto used, and they have also been adapted to the formulæ for the strength of beams given in a work formerly published by the author, entitled, 'Experimental Researches on the Strength and other Properties of Cast-Iron.'—(See Abstract, No. V.)

On the Compression of Short Cylinders of Cast-Iron of Various Kinds.—These experiments contain the decrements in parts of the length, with different weights, up to the crushing weight.

Transverse Strength of Bars and Beams.—Tables I. to X. are on the transverse strength of square bars of Blaenavon Iron, No. 2, of which the lengths were 15 feet, 10 feet, and 5 feet, and the sides of the square 3, 2, 1 inches respectively; with some other bars of different kinds of iron.—(See Abstract, No. VI.)

Table XI. The experiment in this Table, is on the strength of a large beam of cast-iron, the distance between the supports of which was 45 feet, and the depth 28½ inches; the breaking weight being 54 tons nearly.

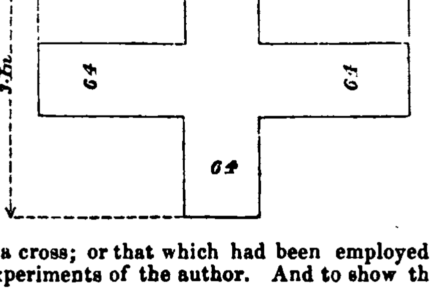
The great labour of an inquiry of this nature, both in making the experiments and in adapting them to their intended purpose, requires the union of much time and many hands; and the author has great pleasure in acknowledging the efficient services derived from one who has been engaged in the matter nearly from the commencement, Mr. Thomas Tredgold, the son of the late eminent writer on these subjects.

Abstract No. I.

TENSILE AND CRUSHING STRENGTH OF CAST-IRON.

RESULTS OF EXPERIMENTS *to determine the ultimate Tensile and Compressive, or Crushing Forces, of various denominations of Cast-Iron in common use; these qualities not having been previously obtained in the Irons tried.*

The experiments are given at large in Tables I., IV., and V. In obtaining the tensile strength in Table I. the form of the castings



was that of a cross; or that which had been employed in all the published experiments of the author. And to show that this was as good, if not better than other forms, besides being, as believed, less liable to theoretical objections than others, experiments were made upon castings with rectangular and circular sections. These experiments are in Table II., and the results from the cruciform section were in all the sound castings somewhat higher than those from the other sections.

In Table I. the specific gravities of 17 kinds of iron are given; they are obtained both from the thickest and the thinnest parts of the castings torn asunder.

Description of the Iron.	Tensile Strength per square Inch of Section.	Height of Specimen	Crushing Strength per square Inch of Section.	Ratio of the Powers to Resist Tension and Compression.	
	lb. tons.	In.	lb. tons.		Mean.
Low Moor (No. 1)..........	12694 or 5·667	¾ 1½	64534 or 28·809 56445 or 25·198	1 : 5·084 1 : 4·446	1 : 4·765
Low Moor (No. 2)..........	15458 or 6·901	¾ 1½	99525 or 44·430 92322 or 41·219	1 : 6·438 1 : 5·973	1 : 6·205
Clyde (No. 1)...........	16125 or 7·198	¾ 1½	92869 or 41·459 88741 or 39·616	1 : 5·759 1 : 5·503	1 : 5·631
Clyde (No. 2)...............	17807 or 7·949	¾ 1½	109992 or 49·103 102030 or 45·549	1 : 6·177 1 : 5·729	1 : 5·993
Clyde (No. 3)...............	23468 or 10·477	¾ 1½	107197 or 47·855 104881 or 46·821	1 : 4·568 1 : 4·469	1 : 4·518
Blaenavon (No. 1)..........	13938 or 6·222	¾ 1½	90860 or 40·562 80561 or 35·964	1 : 6·519 1 : 5·780	1 : 6·149
Blaenavon (No. 2, first sample)	16724 or 7·466	¾ 1½	117605 or 52·502 102408 or 45·717	1 : 7·032 1 : 6·123	1 : 6·577
Blaenavon (No. 2, second sample)	14291 or 6·380	¾ 1½	68559 or 30·606 68582 or 30·594	1 : 4·797 1 : 4·795	1 . 4·796
Calder (No. 1)	13735 or 6·131	¾ 1½	72193 or 32·229 75983 or 33·921	1 : 5·256 1 : 5·532	1 : 5·394
Coltness (No 3)	15278 or 6·820	¾ 1½	100180 or 44·723 101831 or 45·460	1 : 6·557 1 : 6·665	1 : 6·611
Brymbo (No. 1)............	14426 or 6·440	¾ 1½	74815 or 33·399 75678 or 33·784	1 : 5·186 1 : 5·246	1 : 5·216
Brymbo (No. 3)............	15508 or 6·923	¾ 1½	76133 or 33·988 76958 or 34·356	1 : 4·909 1 : 4·963	1 : 4·936
Bowling Iron (No 2)	13511 or 6·032	¾ 1½	76182 or 33·987 73984 or 33·028	1 : 5·635 1 : 5·476	1 : 5·555
Yatalyfera, anthracite (No. 2)	14511 or 6·478	¾ 1½	99026 or 44·610 95559 or 42·660	1 : 6·886 1 : 6·585	1 : 6·735
Ynisceedwyn, anthracite, (1)	13952 or 6·228	¾ 1½	83509 or 37·281 78659 or 35·115	1 : 5·985 1 : 5·638	1 : 5·811
Ynisceedwyn, anthracite, (2)	13348 or 5·959	¾ 1½	77124 or 34·430 75369 or 33·646	1 : 5·778 1 : 5·646	1 : 5·712
Mr. Morries Stirling's, denominated 2nd quality..	25764 or 11·502	¾ 1½	125333 or 55·952 119457 or 53·329	1 : 4·865 1 : 4·637	1 : 4·751
Mr. Morries Stirling's, denominated 3rd quality..	23461 or 10·474	¾ 1½	158653 or 70·827 129876 or 57·980	1 : 6·762 1 : 5·536	1 : 6·149

Abstract No. II.—COLLISIONS AND VIBRATIONS.

Power of Beams of Cast-Iron to sustain long-continued Impact.

The effect of impact and vibration upon structures, was a leading object of inquiry with the Commission; and the first series of experiments instituted upon this subject was, to determine the power of beams to sustain impacts many times repeated. For this purpose, 16 bars were cast, all from Blaenavon Iron, No. 2, and five at least of the 16 were found to be slightly defective at some place where they gave way. Whether these small defects were more numerous than would be found in practice, it would be difficult to determine.

Six of the bars were each 15 feet long and 3 inches square, and placed on supports 13 ft. 6 in. asunder; seven were each 10 feet long and 2 inches square, and 9 feet between the supports; and three were each 5 feet long, 1 inch square, and 4½ feet between the supports. Of these bars, six were bent through ⅓rd of their ultimate deflection at each blow, and five of them bore each 4000 blows without breaking; the sixth was broken at a flaw with 1085 blows. One large bar, bent by impact through $\frac{5}{12}$ths of its ultimate deflection, was broken at a defective place with 1350 blows.

Of six bars bent by blows through half their ultimate deflection, five were broken with less than 4000 blows each; one with 29; one with 127, &c. The only bar which bore the 4000 blows was one of the smallest kind, or 1 inch square.

Of three bars, one bent to $\frac{7}{12}$ths, and two to ⅔rds the ultimate deflection; all were broken; the two latter with 127 and 474 blows respectively: the former required 3700 blows to break it.

Of ten bars of Low Moor Iron No. 2, each 10 feet long and 2 inches square, placed on supports 9 feet asunder, and struck in the middle with long-continued impact, as before, four broke at defective places, and two at sound ones. Three were subjected to impacts, bending them through ⅓rd of their ultimate deflections, and bore the test without fracture; of three bent by blows through half their ultimate deflection, two were broken; those bent through ⅔rds were all broken.

On the whole, it appears that no bar but one, and that a small one, stood 4000 blows, each bending it through half its ultimate deflection; but all the bars, when sound, stood that number of blows, each bending them through ⅓rd their ultimate deflection. It must, however, be borne in mind that a cast-iron bar will be bent to ⅓rd of its ultimate deflection with less than ⅓rd of its breaking weight laid on gradually; and ⅙th of the breaking weight laid on at once, would produce the same effect, if the weight of the bar was very small compared with the weight laid on it. Hence the prudence of always making beams capable of bearing more than six times the greatest weight which will be laid upon them.

TRANSVERSE STRENGTH *to resist long-continued Impact from Balls striking* HORIZONTALLY *against the middle of Bars, the Balls acting as Pendulums with a radius* (r) *of* 17 ft. 6 in.

The bars were cast of three sizes—viz.: 15 feet long and 3 inches square; 10 feet long and 2 inches square; and 5 feet long and 1 inch square. A thin piece of lead, varying from 2 lb. to 4 lb. weight, was generally attached to the side of the bar where struck, to prevent injury to its surface by the impact.

Sixteen Bars of Blaenavon Iron No. 2.

Distance between the Supports.	Side of Square of Bar, nearly.	Weight of Striking Ball.	Assigned Deflection in terms of the ultimate Deflection.*	Number of Blows given to the Bar.	Effect on Bar
	Inches.	lb.			
13 ft. 6 in.	3	151¼	⅓	1085	Broken.†
	3	151¼	⅓	4000	Not broken.
	3	603	⅓	4000	Not broken.
	3	603	$\frac{5}{12}$	1350	Broken.†
	3	151¼	½	127	Broken.
	3	603	½	3026	Broken.
9 feet.	2	75⅝	⅓	4000	Not broken.
	2	603	⅓	4000	Not broken.
	2	75⅝	½	29	Broken.†
	2	75⅝	½	1282	Broken.†
	2	603	½	3695	Broken.†
	2	75⅝	⅔	127	Broken.
	2	603	⅔	474	Broken.
4 ft. 6 in.	1	75⅝	⅓	4000	Not broken.
	1	75⅝	½	4000	Not broken.
	1	75⅝	$\frac{7}{12}$	3700	Broken.†

* The ultimate deflection was obtained from the Experiments on Transverse Pressure.
† Bars slightly defective.

Ten Bars of Low Moor Iron, and one of a mixture of Wrought and Cast Iron.

These bars were cast to be 10 feet long and 2 inches square; they were placed on supports 9 feet asunder. The radius (r) of the pendulum was 17·208 feet when the weight of the striking ball was 603 lb.; and 18·208 feet when the weight of the striking ball was 151¼ lb.

Side of Square of Bar nearly.	Weight of Striking Ball.	Assigned Deflection in terms of the ultimate Deflection.	Number of Blows given to the Bar.	Effect on Bar.
Inches.	lb.			
2	603	⅓	4000	Not broken.
2	603	⅓	4000	Not broken.
2	603	½	608	Broken.[1]
2	603	½	182	Broken.[2]
2	603	⅔	175	Broken.
2	603	⅔	79	Broken.[3]
2	151¼	⅓	400	Not broken.
2	151¼	½	400	Not broken.
2	151¼	⅔	102	Broken.[4]
2	151¼	⅔	38	Broken.
2	603	½	3720	Broken.[5]

[1] Slightly defective on one side
[2] Rather defective on the convex side.
[3] Slight defect or discolouration on the convex side.
[4] The bar broke about 8½ inches from the centre, where there was a defect on the convex side, ½ inch area.
[5] Mixture of wrought and cast iron.

Abstract No. III.—Synopsis *of some of the principal results in the* 19 *Tables of Experiments on the effect of Horizontal Impacts upon Cast-Iron Beams, together with the Breaking Weights and Ultimate Deflections of Beams of the same size, as obtained from* Tables I. *to* VI. *on Transverse Pressure by Vertical Force, and* Table. VI. *on Long Flexible Bars bent by Horizontal Pressure.*

The results set down are means from all the Experiments of each class, and the number of those Experiments is given in Column 2.

Number of Table.	Number of Experiments from which the results are derived.	Distance between the supports.	Dimensions of Bar in direction of Impact.	Dimensions of Bar perpendicular to Impact.	Weight of Bar between the Supports.	Weight of the Striking Ball (Radius, 17¼ feet).	Ultimate Deflection.	Ultimate Chord of Arc of Impact.	Ultimate Vertical Descent of the Ball.	Ultimate Work done by the Ball.	Breaking Weight of a similar Bar, by Transverse Pressure applied Horizontally.	Corresponding Ultimate Deflection by Horizontal Pressure.	Breaking Weight of a similar Bar by Transverse Pressure applied Vertically.	Corresponding Ultimate Deflection by Vertical Pressure.
		Ft. In.	Inches.	Inches.	lb.	lb.	Inches.	Inches.	Feet.		lb. Mean	Inches. Mean.	lb.	Inches.
I.	2	13 6	3·046	3·0355	377·925	603	4·69 and 4·875 from the sound bar.	76·5 and 79· from the sound bar.	1·238	746·51	2665 2912 } 2888	4·939 4·59 } 4·76	2685 from 2 experiments, or 2868 previous to the reduction of the results to those of a bar 3 in. square.	4·6269 from 2 experiments, or 4·5505 previous to the reduction of the results.
II.	2	13 6	1·53	6·122	381·075	603	9+	78·	1·2071	727·88	.. ..	.. ..	.. ..	.. ..
III.	2	13 6	6·095	1·538	383 975	603	2 4 nearly.	80·	1·270	765·81	.. ..	.. ..	.. ..	.. ..
IV.	4	6 9	3·	3·	192·58	603	1·23	56·75	·6390	385·32	6207	1·311	6117 from 3 experiments, or 6440 from bars as cast, or previously to reduction of results.	1·2916 from 3 experiments, or 1·2722 from bars, results not reduced.
V.	2	6 9	1·49	6 095	186·575	603	2·4375	52·75	·5521	332·916	.. ..	.. ..	.. ..	.. ..
VI.	3 struck at the quarter-span	6 9	3·	3·	105·663	603	1·125	66·833	·8861	584·32	.. ..	.. ..	.. ..	.. ..
VII.	2	6 9	3·	3·	189·41	151¼	1·2656 and 1·3125 from the sound bar.	136·5 and 142· from the sound bar.	3·697 and 4·001 from the sound bar.	559·17 and 605·15 from the sound bar.	.. ..	.. ..	.. ..	.. ..
VIII.	4	9 0	2·012	1·988	108·08	603	3·125	39·9	·3159	190·488	1274, 2 inch square exactly.	2·981	1220 from 4 experiments.	2·854 from 4 experiments.
IX.	3	9 0	1·979	2·02	108·15	151¼	2·67 and 2·75 from the sound bars.	72·68 and 80·5 from the sound bars.	1·2408 and 1·2856 from the sound bars.	187·671 and 194·447 from the sound bars.	.. ..	.. ..	.. ..	.. ..
X.	3	9 0	1·974	2·001	106·39	75⅝	2·833	124·	3·0506	230·32	.. ..	.. ..	.. ..	.. ..
XI.	2 (2nd melting).	9 0	1·9905	1·975	108·62	151¼	2·75	93·25	1·7254	260·963	.. ..	.. ..	.. ..	.. ..
XII.	3	4 6	2·	2·	54·	603	·7812	29·3	·1704	102·75	.. ..	.. ..	.. ..	.. ..
XIII.	4	4 6	2·	2·	54·	75⅝	·892	98·5	1·925	145·337	.. ..	.. ..	.. ..	.. ..
XIV.	3	9 0	1·033	2·048	57·12	75⅝	5·00	85·	1·4334	108·223	468 from bars before reduction of results, 415 from bar reduced to exact size from 5 experiments	5 954 6·227, reduced from 5 experiments.	.. ..	.. ..
XV.	3	4 6	1·	2·	28·5	57⅝	.. ..	70·	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
XV*.	3	4 6	2·	1·	28·5	75⅝	.. ..	71·67	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
XVI.	2	4 6	1·0675	1·0845	15·165	75⅝	1·68	52·5	·5469	41·29	447	1·808	440 from 3 experiments.	1·779 from 3 experiments.
XVII. Low Moor, No. 2.	4	9 0	1·984	2·202	105·79	151¼	2·81	84·4	1·413	213 72	.. ..	.. ..	.. ..	.. ..
XVIII. Mixture of Iron from Warrington.	3	9 0	2·01	2·02	111·29	151¼	2·875	99·5	1·964	297·05	1539	3·495	1484 from 1 sound bar.	3·870
XIX. Mixture of iron, supposed to be Mr. Stirling's, called his 2nd quality	4	9 0	1·997	1·982	107·66	151¼	2·58	86·	1·468	222·03	2230, result reduced for 2 inch square, from 4 experiments	2·72	2174, result reduced for 2 in. square, from 4 experiments.	2 652, result reduced for 2 inch square, from 4 experiments.

Remarks on some of the leading Results in the foregoing Abstract.

1st. The bars in Tables I., II., and III. were of the same sectional area, length, and weight nearly, but differed in the form of their transverse section. They were placed on supports at the same distance (13½ feet) asunder, and struck horizontally by the same ball, 603 lb. weight, suspended by a radius of 17 ft. 6 in. From the results given it appears that the beam, 3 in. square, and the rectangular beams, 6 × 1½ in. sections, struck on the broader and narrower sides respectively, had all very nearly the same strength to resist impact. The conclusions are drawn from a mean between two experiments in each case. In Table XV. six bars, each 2 × 1 inch section, and 5 ft. long, were laid on supports 4½ ft. asunder, and all struck by the same ball 75¼ lb. weight, with arcs of a radius 17 ft. 6 in. Three of them were struck on the broader and three on the narrower sides, and their mean chords of impact to produce fracture were 70 in. and 71·67 in. respectively, or nearly the same, agreeing with the results of the experiments upon the former bars.

2nd. In Table IV. the bars were of the same dimensions in section as those in Table I., or 3 in. square, but the distance between the supports was reduced one-half. The resulting breaking deflection, 1·23 in., was somewhat greater than one-fourth of that in Table I., or 4·875 in. and the vertical descent to produce fracture was nearly one-half, but rather more, the depth fallen through in the two cases being ·639 in. and 1·238 in. Comparing, in like manner, the half and whole bars in Tables V. and II., the depths are ·5521 in. and 1·2071 in. respectively. This result, coupled with the former one, shows that the depth fallen through to break the half bar is nearly half of that required to break the whole one. Comparing the results in Tables VIII. and XII., and also Tables X. and XIII., it appears also that a bar of half the length of another resists with nearly half the energy, but somewhat more.

3rd. The experiments in Tables I., II., III., IV., and V. afford illustrations of some of the conclusions in the large generalisation of Dr. Young, deduced from neglecting the inertia of the beam. (*Nat. Phil.*, *Lecture XIII.*) "The resilience of a prismatic beam, resisting a transverse impulse, follows a law very different from that which determines its strength, for it is simply proportional to the bulk or weight of the beam, whether it be shorter or longer, narrower or wider, shallower or deeper, solid or hollow. Thus, a beam 10 ft. long will support but half as great a pressure without breaking as a beam of the same breadth and depth which is only 5 ft. in length; but it will bear the impulse of a double weight striking against it with a given velocity, and will require that a given body should fall from a double height in order to break it."

4th. The experiments in Table VI. were made to compare the effects of striking a bar midway between the centre and one support with those of striking similar bars at the centre, as in Table IV. The great impacts, so near to the support in these cases, would necessarily cause it to yield slightly, and thus increase the resisting powers of the bars to sustain impact. In experiments made by the author several years ago, given in the Fifth Report of the British Association, page 112, on bars 1 in. square—some subjected to impacts in the middle, and others at half the distance between the middle and one support—the chord of impact necessary to produce fracture was nearly equal in the two cases. The ratio of the deflections, from equal impacts at the middle and at one-fourth span, was nearly constant under different increasing degrees of impact; the deflections at the middle from equal impacts being to those at one-fourth span, as 10 : 7 nearly. The relative ultimate deflections of the beam in the middle, and at a point half way between the middle and one end, ought to be as 10 : 7·5 nearly.

5th. The bars in Tables VIII., IX., and X. were all of the same iron and size, and the only difference was in the weights of the striking balls. The distances fallen through, and the work done by the balls to produce fracture, being respectively ·3159 and 190·488 with the 603 lb. ball; 1·2856 and 194·447 with the 151¼ lb. ball; and 3·0506 and 230·32 with the 75¼ lb. ball, affording a good illustration of the resistance from the weight of the bar.

6th. The bars in Table XI. were of the same iron, Blaenavon No. 2, as the others, but re-melted, to ascertain the effect of melting this iron a second time without mixture upon its power to bear impact. The strength to resist blows was increased, but the iron was harder and much more unsound than before. The work done by the ball to break the beam in each case was increased in the ratio of 261 to 194.

7th. The deflections in cast-iron beams were always found to be greater than in proportion to the velocity of impact; whilst in wrought iron they were nearly constant with impacts of very different velocities. This fact shows that there is a falling off in the elasticity of cast iron through impact, analogous to that through pressure. The difficulty of obtaining a satisfactory theory of the power of cast-iron beams to sustain impact is considerably increased by this falling off in elasticity; but it is hoped that the varied nature of these experiments will tend much to reduce it.

Abstract No. IV.

ABSTRACT OF RESULTS ON VERTICAL IMPACTS UPON LOADED BEAMS OF CAST-IRON.

All of the beams were of the same weight and strength nearly. They were placed on supports at a constant distance asunder, and struck in the middle by the same ball, falling through different heights. The object of the experiments was to obtain the effect of additional loads, spread uniformly over the beam, in increasing its power of bearing impacts from the same ball. The beams were of Blaenavon Iron No. 2, cast to be 14 ft. 6 in. long and 3 inches square. The mean weight of beam, 410·7 lb.; mean weight of beam between supports, 382 lb. nearly; distance between supports, 13 ft. 6 in.; weight of ball, 303 lb.

Depth fallen through by Ball before Impact.	Velocity of Impact.	Deflections of Beam when loaded uniformly between the Supports, with Weights in addition to its own Weight, as below.							
		lb. Weight of Beam . 376·765 Unloaded, and without Lead.	lb. Weight of Beam . . 382·1 Lead at centre 4	lb. Weight of Beam . . 375·6 Additional weight in centre . . 28	lb. Weight of beam 387 Additional lead 166 Sum of the two 553 Lead at centre 4	lb. Weight of Beam . . 385·8 Additional Load . . 389·25 Sum . . . 775·05 Lead at centre 4	lb. Weight of Beam . . 387·2 Additional Load . . 389·0 Sum . . . 776·2 No Lead.	lb. Weight of Beam . . 378·8 Additional Load . . 391·2 Sum . . . 770·0 Lead at centre 4	lb. Weight of Beam . 382·65 Additional Load . . 956·25 Sum . . 1338·9 Lead at centre 4
Inches.	Feet.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
9	6·946	1·99	..	..	..	..	..	1·698	..
12	8·0208	2·29	2·154	2·177	2·103	1·942	1·946	2·03	1·483
15	8·967	2·555	2·496	..	..	..	..	2·23	..
18	9·823	2·79	2·585	2·639	2·775 ?	2·426	2 444	2 455	1·883
21	10·610	8·05	2·926	29·09	2·761 ?	..	..	2·66	..
24	11·343	8 21	3·155	8·198	3·149	2·844	2·846	2·87	2·178
25½	11·692	3·33	..	..	..	..	..	..	..
27	12·031	3·49	3·406	8·413	3.871	..	..	3·064	..
30	12 682	Broke with 28½	3·588	8·639	8·613	8·185	3·185	3·215	2·454
31½	12·995	..	3·745	..	..	..	..	..	..
33	13·301	..	Broke.	3 804	8·814	..	..	3·36	..
36	13·892	..	..	8·976	4·045	3 544	3 527	3 585	2·695
39	14·460	..	..	4·164	4·163	..	..	8·665	..
42	15·005	..	..	Broke.	4·283	3·585 ?	8·786	3·82	2·968
45	15·532	..	..	..	4·485	..	..	3·925	..
48	16·042	..	..	..	Broke	Broke.	Broke.	4·128	8·176
54	17 015	..	..	..	..	..	..	4·24	3·388
60	17·935	..	..	..	..	..	..	4·516	Broke.
66	18·810	..	..	..	..	..	..	Broke. }	..

From the preceding table, we see that beams loaded in different degrees, bore more than beams unloaded, as below:—

Additional Load on Beam in lbs.	Height of Fall necessary to break the Beam.	Velocity of Impact answering to that Height.
None	28¼ in.	12·682
Lead, 4lb. weight in centre.. ..	33	13·301
28 lb. in centre; no lead	42	15·005
166 lb. spread over beam + 4 lb. lead	48	16·042
389¼ lb. spread over beam; 4 lb. lead	48	16·042
389 lb. spread over beam; no lead..	48	16·042
391·2 lb. spread over; 4 lb. lead ..	66	18·810
956¼ lb. spread over; 4 lb. lead ..	60	17·935

The set from the impact on these loaded beams was very great, but it did not appear to injure their strength more than in ordinary cases.

By comparing the impacts and deflections in the Abstract above, it will be seen that the deflections are nearly as the square root of the height fallen through by the ball, or as the velocity of impact.

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Abstract No. V.—SYNOPSIS OF EXPERIMENTS ON THE EXTENSION AND COMPRESSION OF CAST-IRON.

1st. *The direct Longitudinal Extension of Rod Rounds, or Bars,* 50 *feet long and* 1 *inch Area of Section nearly, of four kinds of Cast Iron, as mentioned below.*

Number of Table in which the Experiment is described.	Name of Iron.	Number of Experiments.	Mean Area of Section.	Weights, per Square Inch, laid on with their corresponding Extensions and Sets; the last, in each case, being the largest, where all were observed together.			Mean Breaking Weight, per Square Inch of Section.	Mean Ultimate Extension.
				Weights.	Extensions.	Sets.		
			Inch.	lbs.	Inch.	Inch.		Inch.
I.	Low Moor Iron, No. 2	2	1·058	2117 6352 10586 14821	·09500 ·3115 ·5740 ·9147	·00345 ·0250 ·06425 ·12775	16408 lb. = 7·325 tons.	1·085 or $\frac{1}{553}$rd of the length.
II.	Blaenavon Iron, No. 2	2	1·0685	2096 6289 10482 13627	·09422 ·3065 ·5770 ·8370	·00268 ·01675 ·0575 ·11475	14675 lb. = 6·551 tons.	·9325 or $\frac{1}{643}$rd of the length.
III.	Gartsherrie Iron, No. 3	2	1·062	2109 6328 10547 14766 15820	·09225 ·3117 ·5862 ·9452 1·0487	·001 + ·01450 ·0475 ·11325 ·13812	16951 lb. = 7·567 tons.	1·167 or $\frac{1}{514}$th of the length.
IV.	Mixture of Iron, composed of Leeswood, No. 3, and Glengarnock No. 3, in equal proportions.	3	1·063	2107 6322 10536 12643	·0914 ·2967 ·5349 ·6702	·00376 ·01823 ·04321 ·06417	14812 lb. = 6·6125 tons.	·8095 or $\frac{1}{741}$st of the length.

In two of the bars the length, exclusive of the couplings, was 48 ft. 3 in. and the extensions and sets from them have been increased in the ratio of 50 to 48·25, to correspond to a length of 50 feet.

2nd. *The Extensions of Rods* 10 *feet long and* 1 *inch square, deduced from the preceding Experiments, and Compared with observed Compressions of Bars of the same Irons and the same size, cast with them for comparison, together with Formulæ for computing the Weights from the Extensions and Compressions.*

EXTENSION, Table IX.

Number of Experiments.	Weights laid on, with the corresponding Extensions and Sets.				Error in parts of the Weight, when it is computed from the Formula $w = 116117\,e - 201905\,e^2$
	Weights. (*w*.)	Extensions. (*e*.)	Sets.	$\frac{w}{e}$	
9	1053·77	·0090	..	117086	$-\frac{1}{42}$
9	1580·65	·0137	·00022	115131	$-\frac{1}{57}$
9	2107·54	·0186	·000545	113309	$-\frac{1}{119}$
9	3161·31	·0287	·00107	110150	$+\frac{1}{640}$
9	4215·08	·0391	·00175	107803	$+\frac{1}{257}$
9	5268·85	·0500	·00265	105377	$+\frac{1}{163}$
9	6322·62	·0613	·00372	103142	$+\frac{1}{173}$
9	7376·39	·0734	·00517	100496	$+\frac{1}{125}$
9	8430·16	·0859	·00664	98139	$+\frac{1}{155}$
9	9483·94	·0995	·00844	95316	$+\frac{1}{134}$
9	10537·71	·1136	·01062	92762	$+\frac{1}{221}$
9	11591·48	·1283	·01306	90347	$-\frac{1}{674}$
9	12645·25	·1448	·01609	87329	$-\frac{1}{195}$
6	13699·83	·1668	·02097	82133	$+\frac{1}{268}$
4	14793·10	·1859	·02410	79576	$-\frac{1}{80}$

COMPRESSION, Table VI.

Number of Experiments.	Mean Weights laid on, with corresponding Mean Compressions, Sets, and Ratios of Weights to Compressions.				Error in parts of the Weight, when it is computed from the Formula $w = 107763\,d - 36318\,d^2$.
	Weights (*w*.)	Compressions (*d*.)	Sets.	$\frac{w}{d}$	
8	2064·745	·01875	·00047	110120	$-\frac{1}{36}$
8	4129·49	·03878	·00226	106485	$-\frac{1}{816}$
8	6194·24	·05978	·00400	103617	$+\frac{1}{52}$
8	8258·98	·07879	·00645	104823	$+\frac{1}{1330}$
8	10323·73	·09944	·00847	103819	$+\frac{1}{312}$
8	12388·48	·12030	·010875	102980	$+\frac{1}{249}$
8	14453·22	·14163	·01405	102049	$+\frac{1}{179}$
8	16517·97	·16338	·01712	101102	$+\frac{1}{139}$
8	18582·71	·18505	·02051	100420	$+\frac{1}{161}$
8	20647·46	·20624	·02484	100114	$+\frac{1}{649}$
8	24776·95	·24961	·03220	93263	$-\frac{1}{176}$
8	28906·45	·29699	·04300	99331	$-\frac{1}{275}$
7	33030·80	·35341	·06096	97463	$+\frac{1}{64}$
7	37159·65	·41149	·08421	..	..
..	..	..	..	..	..

Extension and Compression of Cast-Iron Bars.

The experiments to determine the effects of various weights, to extend and compress bars of cast-iron longitudinally, were made upon four different kinds of that metal. From the mean results given, in the preceding abstract, of Table IX. on the extension of bars, and Table VI. on their compression, the following formulæ were deduced for expressing the relations between the extensions and compressions of a bar 10 feet long and 1 inch square, and the weights producing them respectively:—

Extension, $w = 116117e - 201905e^2$

Compression, $w = 107763d - 36318d^2$,

Where w is the weight (in pounds) acting upon the bar, e the extension, and d the compression (in inches).

To express the relation between w and the corresponding extension and compression, when the length of the bar is reduced from 10 feet to 1 foot, we assume that the extension and compression are uniform throughout the length of the bar. Therefore the extension or compression of one-tenth its length will be reduced in the ratio 1 : 10. Consequently, in order that the value of w may remain unaltered in the formulæ, the co-efficients of e and d must be increased in the ratio of 10 : 1, and the co-efficients of e^2 and d^2 in the ratio of $10^2 : 1$. These modifications being effected, the formulæ for a bar 1 foot long become

$$w = 1161170e - 20190500e^2 \text{ for extension,}$$
$$w = 1077630d - 3631800d^2 \text{ for compression.}$$

If the bars were 1 inch only in length, those to which the first formulæ applied would be reduced in length in the ratio of 1 : 120.

Consequently the extensions and compressions would be reduced in the same ratio; and in order that w might remain unaltered, the co-efficients of e and d must be increased in the ratio of 120 : 1, and the co-efficients of e^2 and d^2 in the ratio of 120 : 1. These changes being made, the formulæ for bars 1 inch long and 1 inch square become

$$\begin{aligned} w &= 116117\times120e-201905\times120^2 e^2 \\ &= 13934040e-2907432000e^2 \text{ for extension,} \\ w &= 107763\times120d-36318\times120^2 d^2 \\ &= 12931560d-522979200d^2 \text{ for compression,} \end{aligned}$$

where, as before, w is expressed in pounds, d and e in inches.

Lastly, if the length of the bar be l inches, the corresponding formulæ for w may be deduced from those last given, by considering the bar to which those formulæ apply, increased in length in the ratio l : 1. Consequently as before, to adapt the formulæ to the present case the co-efficients of e and d must be diminished in the ratio 1 : l, and the co-efficients of e^2 and d^2 in the ratio of $1 : l^2$.

The formulæ for a bar 1 inch square and l inches in length are, therefore,

$$w = 13934040\frac{e}{l} - 2907432000\frac{e^2}{l^2} \text{ for extension} \quad . \quad . \quad . \quad (A)$$

$$w = 12931560\frac{d}{l} - 522979200\frac{d^2}{l^2} \text{ for compression} . \quad . \quad . \quad (B)$$

The mean tensile strength per square inch of section in the irons experimented upon was 15711 lb. = 7·014 tons, *and the mean ultimate extension for lengths of* 10 feet *was* ·1997 inch, *or* ⅕ inch *nearly, being* 1/600th *part of the length.*

The mean compression of bars of the same metal and dimensions, by the weight 15711 lb. *(the breaking weight by extension, as above stated) was found from the experiments to be* 15488 inch, *or* 1/775th *part of the length.*

To find the values of (*e*) *and* (*d*) *in terms of* (*w*), *in the preceding equations for Cast-Iron.*

$$w = ae - be^2; \quad \text{whence } be^2 - ae = -w;$$

$$e^2 - \frac{a}{b}e = -\frac{w}{b}; \quad e^2 - \frac{a}{b}e + \frac{a^2}{4b^2} = \frac{a^2}{4b^2} - \frac{w}{b};$$

$$\therefore e = \frac{a}{2b} \mp \sqrt{\frac{a^2}{4b^2} - \frac{w}{b}} \quad . \quad . \quad . \quad . \quad (C)$$

Extension of a bar l inches long and 1 inch square in terms of the weight stretching it :—

From equation (A) for elongation of bars of cast-iron, we have, in equation (C),

$$a = \frac{13934040}{l}, \quad b = \frac{2907432000}{l^2},$$

substituting these values of a and b in (C), we have,

$$e = \frac{13934040}{5814864000} \times l \mp \sqrt{\left(\frac{13934040}{5814864000}\right)^2 l^2 - \frac{wl^2}{2907432000}}$$

$$= \cdot00235628l \mp \cdot\overline{00000574215l^2 - \cdot000000000343946l^2w^2}$$

$$\therefore e = l\{\cdot00239628 - \sqrt{\cdot00000574215 - \cdot000000000343946w}\}, \text{ (D),}$$

where w is in lbs. and e in parts of an inch, the negative sign being that alone which is applicable in the quantity under the root.

If $l =$ 1, the extension is that produced by a length of bar = 1 in.
If $l =$ 12, „ „ „ = 1 ft.
If $l =$ 120, „ „ „ = 10 ft.

Example 1. Suppose $w = 11591{\cdot}48$, and $l = 10$ feet or 120 inches, then substituting for w and l their values in equation (D), we have

$$e = l\{\cdot00239628 - \sqrt{\cdot00000574215 - \cdot00000398684}\}$$
$$= l\{\cdot00239628 - \cdot00132488\} = 120 \times \cdot0010714 = \cdot128568 \text{ inch.}$$

Comparing this with the result in Table IX., on extension of bars, from the same pressure 15491·48 lb., we have a defect of 1/478th, the real extension being ·1283 inch.

Example 2. Suppose $w = 2107{\cdot}54$ lb. and $l = 10$ feet; substituting for w and l in equation (D) we have

$$e = l\{\cdot00239628 - \sqrt{\cdot00000574215 - \cdot00000072488}\}$$
$$= l(\cdot00239628 - \cdot00223993) = 120 \times \cdot00015635 = \cdot01876$$

It should be ·0186, ∴ error = 1/116.

Compression of a bar l inches long and 1 in. square in terms of the weight producing it :—

The relation between the weight and the compression being expressed by an equation of a similar form to that between the weight and the extension, or $w = ad - bd^2$, we obtain in the same manner as before,—

$$d = \frac{a}{2b} \mp \sqrt{\frac{a^2}{4b^2} - \frac{w}{b}}$$

substituting the values of a and b derived from the equation (B) for cast-iron, or $\frac{12931560}{l}$ for a, and $\frac{522979200}{l^2}$ for b, we obtain—

$$d = \frac{12931560}{1045958400} \times l \mp \sqrt{\left(\frac{12931560}{1045958400}\right)^2 l^2 - \frac{wl^2}{522179200}}$$

$$= l\{\cdot012363359 - \sqrt{\cdot000152853 - \cdot00000000191212w}\}. \quad . \text{ (E)}$$

Where w is in pounds and d in inches, the quantity under the root is affected by the negative sign, which alone is applicable in this instance.

Example 1. If $w = 8258{\cdot}98$ lb., and the length 10 feet = 120 inches, we obtain by substituting the value of w and l in equation (E),—

$$d = l\{\cdot012363359 - \sqrt{\cdot000152853 - \cdot00001579216}\}$$
$$= (\cdot012363359 - \cdot0117073)\,l = \cdot07872 \text{ inch.}$$

Comparing this with the experimental result for this pressure in Table VI. on compression of bars, or ·07879, we find the deviation or error equal 1/1125 of the latter.

Example 2, If $w = 6194{\cdot}24$ lb. and $l = 120$ inches as before,

$$d = l\{\cdot012363359 - \sqrt{\cdot000152853 - \cdot0000118441}\}$$
$$= l(\cdot0004890) = \cdot05868 \text{ inch.} \quad \text{It should be } \cdot05978 \; \therefore \text{error} = \tfrac{1}{54}\text{th.}$$

The first example is the case of least deviation of the formula from the results of experiments in Table VI.; and the second is that of greatest deviation for pressures between 2 and 14 tons per square inch, the range between which the results are most trustworthy.

Example 3. If $w = 15711$ lb.—the weight which would tear asunder an inch bar of these irons—to find the compression of a bar 10 feet long and 1 inch square from the same weight.

Substituting in equation (E) the values of w and l,

$$d = l\{\cdot012363359 - \sqrt{\cdot000152853 - \cdot00000000191212w}\}$$
$$= l(\cdot012363359 - \cdot0110820) = l(\cdot0012813) = \cdot15376 \text{ inch.}$$

The decrement, as obtained from the results of experiment in Table VI., on compression of bars, was ·15488 inch.

Extension.

(Computed from the Formula obtained.)

Weight.	Computed Extension.	Real Extension.	Error in parts of Real Extension.
1053·77	·00922	·0090	+ 1/41
2107·54	·01876	·0186	+ 1/116
4215·08	·03893	·0391	− 1/230
6322·62	·06090	·0613	− 1/153
8430·16	·08523	·0859	− 1/128
10537·71	·11293	·1136	− 1/170
12645·25	·14593	·1448	+ 1/128
14793·10	·19051	·1859	+ 1/40

Compression.

Weight.	Computed Decrement.	Real Decrement.	Error in parts of Real Decrement.
2064·745	·01928	·01875	$+\frac{1}{35}$
6194·24	·05863	·05978	$-\frac{1}{52}$
10323·73	·09909	·09944	$-\frac{1}{284}$
14453·22	·14077	·14163	$-\frac{1}{165}$
18582·71	·18379	·18505	$-\frac{1}{147}$
24776·95	·25114	·24961	$+\frac{1}{163}$
33030·80	·34705	·35341	$-\frac{1}{56}$

Transverse Flexure.

When a beam is bent in any degree the fibres or particles on the convex side are extended, and those on the concave side are compressed; and there is a line within the beam, intermediate between the two sides, in any transverse section where the particles are neither extended nor compressed. This is called the neutral line, and the particles on each side of it are stretched or compressed according to their distance from it; but the *force* exerted by these particles is not in proportion to the distance, in cast iron, at least, which we are treating of. It varies as a function composed of the first and second powers of the distance nearly.

Thus, in the longitudinal extensions and compressions of a bar one inch area of section and l inches long, we have from the mean results of experiments on four kinds of cast-iron, equations (A) and (B),

$$w = 13934040\,\frac{e}{l} - 2907432000\,\frac{e^2}{l^2},$$

$$w = 12931560\,\frac{d}{l} - 522979200\,\frac{d^2}{l^2},$$

where w is the weight in pounds producing the extension e or compression d in inches.

To apply this to transverse pressure, suppose the extension e and compression d of a small length of the material at a distance l from the neutral line to be represented by ml, $m'l$, respectively, then the extension and compression at any other distance x of a portion of the material originally of the same length will be mx and $m'x$, and the formulæ will become—

$$w' = 13934040\,\frac{mx}{l} - 2907432000\,\frac{(mx)^2}{l^2} \quad . \quad . \quad . \quad (F)$$

$$w'' = 12931560\,\frac{m'x}{l} - 522979200\,\frac{(m'x)^2}{l^2} \quad . \quad . \quad . \quad (G)$$

where w', w'', are the forces of tension and compression exerted by the fibres at a distance x from the neutral line, and m, m' co-efficients dependent on them.

In the 'Experimental Researches on the Strength of Iron, published by the author, and forming an additional volume to 'Tredgold on Cast-Iron,' an attempt was made to give a more general computation of the strength of beams than had hitherto been done, the solution depending upon the supposition that the resistance of the particles to tension and compression varied in terms of the 1st and some other constant power of the extension and compression. Thus if x be the distance from the neutral line—

$$\phi\,(x) = x - \frac{x^v}{na} = x - \frac{x^2}{na},\ \text{if } v = 2 \quad . \quad . \quad . \quad . \quad (J)$$

$$\phi'(x') = x' - \frac{x'^{v'}}{n'a} = x' - \frac{x'^2}{n'a},\ \text{if } v' = 2 \quad . \quad . \quad . \quad (K),$$

where $\phi\,(x)$ and $\phi'\,(x')$ would be quantities respectively proportional to the forces of extension and compresssion of a particle at a distance x from the neutral line, and n, n', quantities supposed to be constant.

From the experiments given in this inquiry, it appears that v, v', are equal to 2; and in the equations (J) and (K) a is the same quantity as l in equations (F) and (G), $a = l$; and to adapt the formulæ (F), (G), for cast-iron, found before, to the forms above, we have—

$$\frac{w'l}{13934040\,m} = x - \frac{2907432000\,m^2 l}{13924040\,ml^2} \times x^2$$

$$= x - \frac{2907432000\,m}{13934040} \times \frac{x^2}{l},\ \text{for extension} \quad . \quad . \quad . \quad . \quad (L)$$

In like manner—

$$\frac{w''l}{12931560\,m} = x - \frac{522979200\,m'}{12931560} \times \frac{x^2}{l},\ \text{for compression} \quad . \quad (M)$$

Whence we obtain the values of n, n', in equations (J), (K), as below,—

$$n = \frac{13934040}{2907432000\,m},\ n' = \frac{12931560}{522979200\,m'}$$

By inserting these values in the formulæ given in the work above referred to, the position of the neutral line and the strength of a cast-iron beam of the form considered may be found.

Abstract No. VI.

Abstract *of Results on the Transverse Strength of Cast-Iron Bars of different sizes, but mathematically similar, or relatively proportional in all their dimensions.*

The bars were of Blaenavon iron, No. 2, and were respectively cast to be 3, 2, and 1 inches square, and 15, 10, and 5 feet long. They were placed on supports 13½, 9, and 4½ feet asunder, and the strength and ultimate deflections of the bars, when reduced to their exact size, were as below:—

Size of Bars.		Vertical Pressures.				Horizontal Pressures computed from the Vertical Pressures.			
		Strength.		Ultimate Deflection.		Strength.		Ultimate Deflection.	
Ft. span.	In. sq.	lbs.	Mean	Inches.	Mean.	lbs.	Mean.	Inches.	Mean.
4½	1	461 437 423	440	1·796 1·850 1·6917	1·779	468 444 430	447	1·823 1·880 1·720	1·808
9	2	1249 1414 1121 1097 1552*a* 1594*b*	1338	2·996 3·486 2.527 2·498 3·620 2.984	3 0035	1303 1469 1175 1151 1616 1648	1394	3·032 3·622 2·649 2·621 3·746 3·085	3·126
13½	3	2698 2671 3389*c* 2686*d*	2861	4·863 4·3908 5·024 4·391	4·667	2877 2854 3573 2869	3043	5·186 4·692 5·297 4·690	4 966
6¾	3	6341 5795 6215	6117	1·3319 1·190 1·353	1·2916	6431 5885 6306	6207	1·351 1·208 1·373	1·311

The results marked with the letters *a*, *b*, *c*, *d*, are from the bars which had been previously subjected to 4000 impacts, each bending them through ⅓rd of their ultimate deflections.

The strengths of similar bars 1, 2, 3 inches square, and 4½, 9, and 13½ feet between the supports are respectively 447, 1894, and 3043 lb. to resist an horizontal pressure.

If the elasticity of the beams had been perfect, their strengths should have been as the square of their lineal dimensions, or as 1, 4, 9. Dividing, therefore, the strengths as above by these squares, the quotients ought, on this supposition to be equal. We have, however,

$$\text{From the smallest bars} \quad . \quad . \quad \frac{447}{1} = 447,$$

$$\text{From the next larger bars} \quad . \quad \frac{1394}{4} = 349,$$

$$\text{From the largest bars} \quad . \quad . \quad . \quad \frac{3043}{9} = 338.$$

The quotients are unequal; but we see that the deviation from theory, on the supposition of perfect elasticity, is much greater in the smaller than in the larger bars, and that the strength of the smallest bar is greatly above that derived from others, partly, it is probable, arising from defect of elasticity, but principally from the superior hardness of the smaller castings.

The ultimate deflections of similar elastic bars from horizontal pressure are as the lineal dimensions of the bars, nearly; and, therefore, similar bars, one, two, and three inches square, ought to deflect before fracture in those proportions. The ultimate deflections from experiments, as above, are below.

In bars, 1 inch square	. . . .	1·808
„ 2 inches square	. . .	3·126
„ 3 „	. . . .	4·966

The deviation in the ultimate deflection of the bars, from 1, 2, 3, the ratio of their size, is, therefore, larger in the smallest (hardest) bars than in the others.

In Tables V. and IX., on the transverse strength of bars, of wrought and cast-iron mixed, we find a similar falling off to that above, in the strength of the larger bars below that of the smaller ones, as is shown in the following extracts:—

Size of Bar.		Strength to bear Horizontal Pressure.		Ultimate Deflection from Horizontal Pressure.
Ft. Span.	In. sq.	lb.		
9	2..	2230	from 4 experiments on 1st sample	2·720 in.
		1545	from 2 experiments on 2nd sample	2·258
4½	1..	630	from 4 experiments on 1st sample	1·4995
		505	from 4 experiments on 2nd sample	1·320

General Remarks on the Rapidity of Increase of Transverse Strength of Square Bars for Small Increments of their Sectional Dimensions.

The rapidity with which the transverse strength of square bars increases for small increments of their sectional dimensions does not appear to have been always adequately considered in experimental inquiries. *For square bars of constant length between the supports, the transverse strength varies as the cube of the side of the square,* consequently, for bars not greatly exceeding 1 inch square,—such as have most frequently been subjected to series of experiments,—an error of 1/10th of an inch (for example) in the sectional dimensions, will produce an error of nearly ⅓rd in estimating the transverse strength. It is, however, by no means unusual to assume bars, cast to be 1 inch square, to have exactly their nominal dimension; variations of the actual dimensions, sometimes approaching to, or even exceeding 1/10th of an inch, being neglected.

This source of error has been avoided in the present series of experiments,—and in nearly all others by the author,—by measuring the transverse dimensions of each bar to thousands of an inch, and reducing the results by theory to those for the intended size of the casting. The nature and extent of the error will be easily seen by the following table, in which is exhibited the difference of strength of square bars, of which the transverse dimension increases by hundredths of an inch. The breaking weight of the bar 1 inch square is taken at 448lb. (from the mean of experiments on cast iron). It will be observed from this table, that an error of less than 1/12th of an inch in the measure of the side of the square bar produces an error of ¼th of the strength. A similar error of 1/10th of an inch produces an error of ⅓rd the strength, and an error of less than 1/7th of an inch produces an error of ½ the strength.

Comparative Transverse Strength of Bars of Sections slightly differing from 1 square inch.

Side of Square of Bar.	Cube of Side.	Strength, or Breaking Weight.	Approximate Error from assuming the Bar as 1 inch Square.
1·00	1·000	448	..
1·01	1·0303	462	1/32
1·02	1·0612	475	1/17
1·03	1·0927	489	1/11
1·04	1·249	504	1/8
1·05	1·1576	519	1/6
1·06	1·1910	534	1/5
1·07	1·2250	549	5/22
1·08	1·2597	564	1/4
1·09	1·2950	580	5/17
1·10	1·3310	596	1/3
1·11	1·3676	613	10/27
1·12	1·4049	629	2/5
1·13	1·4429	646	10/23
1·14	1·4815	664	1/2
1·15	1·5209	681	10/19

NEW WESTMINSTER BRIDGE.

Sir—Several designs have been given in for building a new bridge across the river Thames at Westminster. The designs have been lithographed, and are to be found in the "Third Report, Westminster Bridge and New Palace, ordered by the House of Commons to be printed 5th August, 1846."

The design proposed by Mr. Walker, for a stone bridge, consists of five arches, segments of circles, and the information regarding those arches, as stated in the design, is as follows:—

> "Span of centre arch, 150 feet.
> Span of side arches, 140 and 120 feet.
> Soffit of centre arch above Trinity standard, 24 feet."

The versed sine or heights of those five arches above the springing line have not been figured in on the design, nor the radius of any of the arches. The figured dimensions of the piers are omitted, and also the radius of the curve which the soffits of the five arches should tangent; but by measuring on the design, the versed sines or heights of the first and last arches between the springing line and their soffits have been found to be each 15 feet, and the centre arch about 20 feet. The thickness of the piers, measured on the plan, 18, 20, 20, and 18 feet, making a total of 76 feet. The distance across the river, between the abutments, 746 feet, and the clear waterway 670 feet. The horizontal distance, or length of the chord line between the versed sines of the first and last arches, is 626 feet.

The spans of the arches of 150, 140, and 120 feet, have all different radii. Have they been put into the design at random? or have they been the result of calculation emanating from some rule of science? Has this been the reason of the engineer having omitted to figure in the versed sines of the five arches on the plan?

A design for an iron bridge is also given by Mr. Walker, with a short note, as follows:—

> "Span of centre arch, 150 feet.
> Span of side arches, 140 and 120 feet.
> Soffit of centre arch above Trinity standard, 24 feet."

This makes a clear waterway of 690 feet, whereas Mr. Walker's design for a stone bridge gives only a waterway of 670 feet, being a difference of 20 feet of waterway between the two designs. This is the very limited and variable information contained in Mr. Walker's two designs for a bridge over the Thames at Westminster.

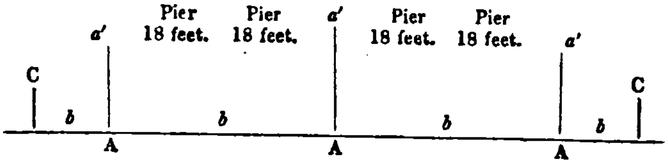
Mr. George Rennie has given in a design for a stone bridge, consisting of seven elliptic arches; the spans of the arches and their heights have been figured in on the design. The waterway of the seven elliptic arches is 760 feet, and the width between the abutments, 832 feet, which varies greatly from the dimensions given by Mr. Walker.

	Waterway.	Width between Abutments.
Mr. Rennie's bridge of seven arches	760	832
Mr. Walker's stone bridge, five arches	670	746
Difference	90	86
Mr. Rennie's bridge of seven arches	760	832
Mr. Walker's iron bridge, five arches	690	756
Difference	70	76
Mr. Walker's iron bridge, five arches	690	756
Mr. Walker's stone bridge, five arches	670	746
Difference	20	10

Mr. Barry's iron bridge of five arches has a waterway of about 720 feet, but no figured dimensions have been given.

As your *Journal* is read by many intelligent persons well acquainted with calculations and the properties of the circle, perhaps some of them would be kindly pleased to give the solution of the following problem, and the formulæ on which the solution and calculations have been based.

Elements given.



	Feet.
Distance between the abutments, C, C	746
Ordinates between A, a'	15
Ordinates between A, a'	20
Ordinates between A, a'	15
Horizontal distance between the ordinates	313
The width of each of the five segment arches by calculation, all of the same radii, to span a waterway of	670
Four piers, two on each side of the centre arch to be 20 feet thick each, and two at the side arches 18 feet thick each; the breadth or thickness of the whole four piers	76

b, *b*, *b*, *b*, line, from which the arches are to spring.

a', *a'*, *a'*, three points through which a curve line shall pass, and tangent the soffits of the five segment arches.

Required from the above Elements.

1. To determine the radius of the curve which shall pass through the three points *a'*, *a'*, *a'*, and which shall tangent the soffits of the five segment arches.

2. To determine by calculation the span of each of the five segment arches, which shall, when added together, give a waterway of 670 feet in width; and, with the thickness of the four piers, 76 feet broad, a space of 746 feet in width between the abutments or points C, C.

3. To determine by calculation the versed sines of each of the five arches.

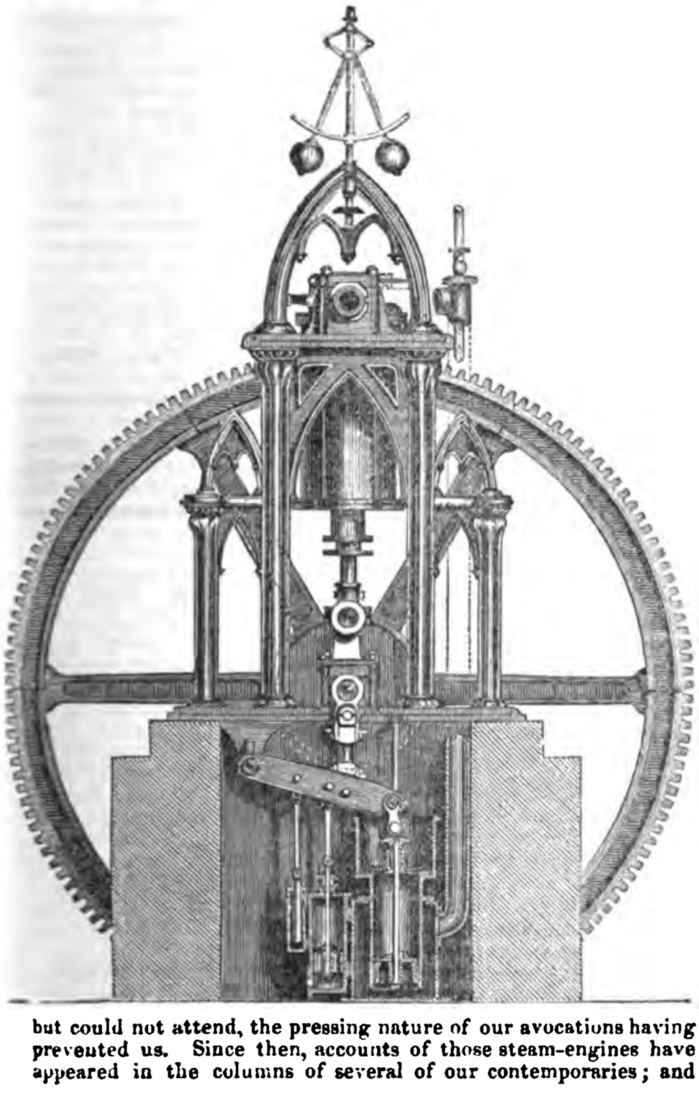
4. The soffits of the five segment arches to tangent the curve line which shall pass through the three points *a'*, *a'*, *a'*.

5. The length of the radius which shall be common to the five segment arches contained between the springing line *b*, *b*, *b*, *b*, and the curve line passing through the three points *a'*, *a'*, *a'*.

February, 1850. B.

THE SMYRNA STEAM FLOUR-MILLS
AND
THE WATT AND WOOLF STEAM-ENGINES.

On Saturday, the 19th of January last, a private view of two powerful steam-engines, on the Woolf principle, but with oscillating cylinders, took place at the works of the Messrs. Joyce, engineers, Greenwich: we would rather say, a public view, the admittance being by invitation and by card. We were invited to be present, but could not attend, the pressing nature of our avocations having prevented us. Since then, accounts of those steam-engines have appeared in the columns of several of our contemporaries; and from one of them, the *Mining Journal*, we shall take leave to extract the following:—



> " The engines which the Messrs. Joyce have constructed for this purpose, have been formed upon a principle entirely new in this country, which has been found to work with unexampled advantage in several establishments in which the same kind of engines has been adopted. In their general arrangement, they may be described as belonging to the class of steam-engines termed " oscillating," from the circumstance of their cylinders vibrating on axes or trunnions, in order that the piston-rods may constantly act upon the cranks without the intervention of what in stationary engines is termed a parallel motion, a contrivance, by which the vertical motion of the piston-rod is adapted to the circular motion of the cranks. The principle discovered by Woolf, of introducing steam of a high-pressure into a small cylinder, and allowing it to act expansively in a larger one at a pressure smaller than the original, in the proportion of the circular sections of the cylinders, and afterwards to add to its effective force by condensation, is here applied in an extremely ingenious manner, and with a simplicity of arrangement having reference to the multiplicity of objects which are to be provided for simultaneously in the machine. But what Woolf did by the intervention of parts which rendered the action indirect, is here done without the aid of subsidiary arrangements, and the action is direct. The oscillating cylinders are for this purpose inverted, and vibrate upon steam-ways at their upper extremities. The long horizontal shaft upon which the piston-rods act, is furnished with cranks, so that the dead point is always got over, and the motion transmitted by cogged-wheel gearing, the large wheel being 16 feet ni diameter—the fourteen mills, each of which is furnished with a pair of millstones, grinding in the usual way.
>
> A report from Mr. Elijah Galloway, C.E., who was employed by Mr. T. Comer, to examine the machinery for him, is now before us, from which we gather, that the capacity and dimensions of the engines and machinery are in all respects, more than ample both for power and strength—the engines, moreover, being equal to nearly double the power required. With reference to the four boilers employed to generate the requisite quantity of steam, Mr. Galloway expresses his conviction that *one* alone will be nearly capable of supplying both engines, thus affording the command of full three times the power required, and which would, in his opinion, work safely at " double the proposed maximum pressure." The report concludes with expressing the great satisfaction on his part of the economy attendant on the application of the machinery, and the nicety and perfection with which it has been constructed.
>
> In the course of conversation we were given to understand that an engine of 12-horse power, at the Greenwich Iron Works, upon the principle referred to, costs only 30*s*. per week for 12 hours per day, while several establishments at home and abroad, prove the consumption of fuel to be less than 3 lb. per horse power per hour."

Similar accounts to the preceding have appeared in the other publications to which we have had occasion to allude. Those accounts are of so extraordinary a nature, and so apt to impress the public mind, either with error or doubt—error with those who do not thoroughly comprehend the construction and principles of the steam-engine, and doubt with those who do—that we feel ourselves impelled, by a sense of public duty, to make some comments.

This course appears to us to be the more incumbent—the more imperative, as it shadows forth a matter of considerable interest at this present time—the comparative value of the Watt and the Woolf steam-engines.

In the cotton-spinning districts of Glasgow and Manchester, many Woolf-engines have been erected recently; and others, by the addition of another cylinder, and by working the steam at high pressure in the new cylinder, and expanding it in the old, have been changed into Woolf-engines.

These introductions and adaptations have taken place since the Woolf-engine has been re-patented by Mr. MacNaught, of Glasgow; and, as we have received letters from several gentlemen, interested in cotton-spinning, claiming our particular attention to the matter, which is of importance to them, we shall now enter upon the subject.

In the foregoing accounts it is stated, that the Messrs. Joyce, the engineers of Greenwich, have made a pair of magnificent and powerful steam-engines, with all the appurtenances of a flour-mill, to work fourteen pair of stones; that " the engines *are on the double-cylinder expansive plan*, originally patented by Woolf;" that " the Messrs. Joyce have succeeded in giving a *direct* action to that which Woolf and his followers gave *indirectly*, by which, amongst other beneficial results, the consumption of fuel *is less than* 3 lb. *per horse power*, it being about 12 lb. under the old system;" *and that " these results have been mainly achieved by the introduction of a system of inverted and oscillating cylinders*, which cause the force of the piston-rods to act directly upon the crank-pin, without the interposition of any intermediate machinery, so that the friction of the whole engine is reduced to its minimum, *while its simplicity proportionably reduces the chances of accident.*"

Now, Woolf, to the best of our recollection, patented his double-cylinder expansive steam-engine in 1804; and, in conjunction with his partner, Mr. Edwards, erected one at the saw-mills at Lambeth; afterwards and now in the possession of Mr. Smart, where we saw it working in 1825. He erected one also, we think, at the brewhouse of Messrs. Meux and Co., where he gave a public challenge to Messrs. Boulton and Watt, which excited much attention. Mr. Woolf shortly afterwards went into Cornwall, and erected some at the mines there, the duties of which, by the consumption of each bushel of coal, were so unprecedentedly great, that the attention of the mining interests of that county was publicly engrossed by it. But more of this anon.

Steam-engines, on the double-cylinder expansive principle of Woolf, were afterwards erected in the neighbourhood of London, by Messrs. Pullen and Wentworth, of Wandsworth; particularly for flour-mills on the river Wandle. We had occasion in 1836, to make a professional survey of the power and effect of the mills on that stream—both those impelled by steam and those impelled by water. We then saw several of the steam-engines that had been so erected; also others at the engine-yard of Messrs. Pullen and Wentworth; also one at a flour-mill at Bermondsey. We state these things to show, that although steam-engines on this principle have been long well-known, they have not met with the general recognition and sanction of our best engineers.

It was the latter part of 1814 that Woolf's engine, with the double cylinder, was introduced into Cornwall. The large cylinder was 45 inches diameter. It was erected at the mine called "Wheal Abraham." Its duty, as first reported, in October of that year, was 34 million pounds lifted 1 foot high, by the consumption of each bushel of coal, weighing 92 lb. It was discovered soon afterwards that there was a defect in some of the castings which being removed, the duty advanced in the following year, to upwards of 52 millions. A second engine, with a 53-inch cylinder, was erected next year by Woolf, at Wheal Var. Its duty was 50 millions. These duties, which were tested and verified, produced much excitement, as well they might, amongst the mining interests of Cornwall; for at that time the number of other engines reported at the mines was 35, and the average duty was 20½ millions.

In 1816, Messrs. Jeffree and Gribble erected a new engine *with single cylinder* at Dolcoath, 76 inches diameter. Its duty amounted to 40 millions. Sims also erected one at Wheal Chance, which attained to 45 millions. Woolf, in 1820, erected *a single-cylinder* engine at the Consolidated Mines, 90 inches diameter and 10 feet stroke; its duty in December of that year reached 38½ millions. At this period, "*Woolf's engines with double cylinders, owing to the difficulty of keeping them perfect, had fallen to the average of the best single-cylinder engines; and after this period began to be disused in the mines.*"[*]

In 1825, Sims erected *a single-cylinder* engine at Polgooth, which performed 54 millions; in 1827, Captain William Grose erected one at Wheal Towan, the duty of which was 62 millions; and in October of that year, Woolf's 90-inch *single cylinder*, at the Consolidated Mines, reached the hitherto unprecedented duty of 67 millions. These duties were shortly afterwards surpassed by Grose's engine, at the Wheal Towan, in 1828, reaching 87 millions; and that of Mr. William West, at the Fowey Consols and Lanescot Mines, attaining to 125 millions, which is the highest amount of duty yet recorded.

We state these things to show, that although the mining interests of Cornwall gratefully acknowledged themselves indebted to Woolf for first pointing out to the engineers of that important district, the advantages of using high-pressure steam worked very expansively, and which led them to adopt their present simple and effectual mode of using and expanding the steam in one cylinder only; yet they have found it necessary, entirely to supersede his more complicated and costly machines, the double-cylinder engines.

Thus far examined, therefore, we cannot perceive what advantage the Messrs. Joyce propose to themselves by the adoption of the *double-cylinder* Woolf-engine. Most engineers, we believe, thoroughly conversant with the constituencies of steam and the action of the steam-engine, are aware that the only advantage Woolf conceived he could gain by using the double-cylinder engine was, that of working the steam expansively. The idea of employing steam *expansively*, originated with the great James Watt; and for its use or application he obtained letters patent. He proposed to employ the principle in a *single-cylinder* engine; Woolf in an engine with *two cylinders*. The timidity of James Watt deterred him from employing steam of very high pressure, or at from 40 to 60, or to 80 lb. on the square inch beyond the atmosphere. Woolf, having no fears of the kind, had recourse to it; and as the expansive force of steam, for practical purposes, becomes more tangibly apparent at high degrees of pressure than at low, Woolf derived the advantage. In no other respect was any superiority in the Woolf-engine made manifest. The shrewd, practical, mining engineers of Cornwall soon discovered this; and, in their practice, abandoned the complicated double-cylinder engine of Woolf, for the single cylinder of James Watt. For it may be averred, that the *single-cylinder* steam-engine now used in Cornwall, although better proportioned in some of its parts and larger in dimensions—although the steam employed is of much higher pressure, and more attention is paid to the preservation of it by non-conducting substances, —is truly, *and unquestionably*, the simple *single-cylinder steam-engine* of the great James Watt.

We therefore repeat, we cannot perceive what advantage the Messrs. Joyce propose to themselves, by adopting a principle which has been tried, and "*found wanting;*" in other words, by having recourse to the complex apparatus of Woolf, when the simple arrangement by Watt is found to be equally as efficient.

It may, perhaps, be urged, that although expanding steam in a single-cylinder engine may answer very well for pumping, where the motion at both ends of the stroke is intermittent; yet it will not answer so well in rotatory fly-wheel engines where the motion is continuous, and intended to be equable. But here we must be permitted to dissent from any such opinion. The expansive system is now very commonly adopted to rotatory fly-wheel engines by our best engineers; and we ourselves were principally instrumental to its first adaptation to the delicate processes of the cotton manufacture, where some of the spindles make from seven to eight thousand revolutions in a minute, and where the least variation of speed would produce a very perceptibly injurious effect. If the expansive system can be used under such circumstances, surely it may be similarly employed to a flour-mill, which does not need such precise equability of motion, and where the stones that grind the flour do not revolve generally at a greater speed than from 120 to 140 revolutions per minute? We repeat, therefore, we cannot perceive what advantage the Messrs. Joyce propose to themselves by adopting a complex apparatus instead of the simple one.

In the same paper it is stated, that the Messrs. Joyce derive much important advantage *by the adoption of vibrating or oscillating cylinders*, which require no beam, and by which the power is communicated direct from the steam-piston to the crank.

This also was a discovery of the great James Watt, who took out a patent for its application. For some cause or other, it remained dormant a great many years. In or about the year 1828, the principle was carried into successful practical operation by that highly eminent firm, Messrs. Maudslay, Son, and Field, in consequence of Mr. Joseph Maudslay having invented, and taken out letters patent for, a method of applying the long D slide to the vibrating cylinder. This was the *first* application of the oscillating cylinder to the steamboat, which has since become so general in boats intended for river navigation. We were present at the first experimental trip, having been invited by that able engineer and splendid mechanician, the late Henry Maudslay, Esq. There were present, besides the late Mr. Maudslay and his son, the inventor, Mr. Joshua Field, Mr. Bryan Donkin, the late Sir Isambert Marc Brunel, and others, whose names confer weight, honour, and dignity to the profession. The experimental trip was from London to Richmond, and back again. It took place at a time when there was a heavy flood of water in the Thames. The boat was of light draft, the engines were powerful, and it answered admirably well.

That the oscillating principle is well adapted to boats of light draft, there cannot, we think, be a difference of opinion. But we must be pardoned, if we doubt its equal applicability to stationary purposes. At any rate, we cannot perceive how it is that so great an advantage has been obtained by the adoption of this principle of construction, added to that of the double cylinder of Woolf, as is now stated to be; and by which it is affirmed, that the quantity of coal consumed for each horse power per hour, is less than three pounds.

We cannot give credence to this statement; nor can we believe that it has been given to the public with the sanction of so respectable a firm as the Messrs. Joyce. We cannot perceive in what respect these engines can consume less coal, per horse power, than other kinds of engines, with beams or without beams, equally well

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[*] "Historical Statement of the Improvements made in the Duty performed by the Steam-Engines in Cornwall." By Thomas Lean and Brother, Registrars and Reporters of the Duty of Steam-Engines. London: Simpkin and Marshall. 1839.

constructed. If we be in error, we shall be glad to be set right; and shall be rejoiced to be become acquainted with the minutiæ of so important and so gratifying a fact, that a rotatory fly-wheel engine, for land purposes, can be made to do with *three pounds of coal* per each horse power per hour.

We still doubt the fact: if we be in error, we respectfully invite the Messrs. Joyce to verify the statement, by making known to the public, through our *Journal*, the following particulars to guide them:—

Diameter of each steam-cylinder, and length of stroke?

At what pressure the steam was worked in the small cylinder?

The number of strokes made per minute?

The diameter and weight of the mill-stones; and the number of revolutions made by them per minute?

The quantity of wheat ground per hour, when the bolting and dressing machines were at work as well?

The nominal power of the engines?

And the quantity of coal consumed?

We shall be glad also to learn, whether the consumption of coal per each horse power, per hour, were estimated on the full indicated power—inclusive of friction, the power consumed by the pumps, &c.; or whether it were given to the world on the nominal horse power, as it ought to have been? If on the former, its tendency is, most unquestionably, to convey an erroneous impression.

We shall be glad to hear from the Messrs. Joyce on this subject.

THE HEALTH QUESTION—WATER SUPPLY ADMINISTRATION.

Although there have been successive agitations for better water, each of which has died away, yet the time now comes when the public is in earnest, and something will be done, so that the question only remains how. Undoubtedly it is of much importance, that the best spring should be gone to; but it is of much more moment, that the best mode of management should be resorted to. When we say "the best," we do not mean the best theoretically, but that which will work most energetically, and in which the public will have most confidence. This, too, is a matter which as much interests our readers as the levels and pressures incident to the water supply. Indeed, what can interest them more than to know who are to be their employers? Further, it must not be lost sight of, that the great progress in the water movement, as in the drainage and other improvements for health, is owing to the engineers. Engineers have shown, that water can be cheaply raised, efficiently filtered, and sent into the houses as a constant supply, just in the same way that by improvements in the form and construction of sewers, they paved the way for the extension of the sewage system. Mr. Chadwick has done much; medical men have done much; but the share of the engineers, although little noticed by the public, and purposely kept out of sight by the government, is none the less worthy of regard. As is too common, those who halloo the loudest are those most looked to; and those who do the work, forgotten. It is much harder to lay down a good and cheap sewer than to make an outcry about want of drainage; and yet he who does the work gets the least reward.

This unsatisfactory state of affairs is, to a great degree, dependent on the system of management now adopted, and for this reason in particular we now take up the pen, in the hope of gaining the co-operation of our readers. Hitherto the system has been bad; but care must be taken, that in making alterations, one bad system is not substituted for another; or, indeed, a worse system for what is now bad enough. The water companies have failed to work well,—the Sewers Commission is unsettled,—the Health Commission is only in a provisional state,—the management of streets, paving, and lighting is disorganised.

We know there is one favourite panacea in Downing-street government management; and there is a strong push made to bring it to bear on the water supply, but with no sufficient reason. If there were formerly people weak enough to believe that government management is perfection, that belief is now shaken. Every paper that comes out, gives the fullest and strongest proofs of government mismanagement; and the last year's exposures have been awful. We knew before how bad are the Post Office, the Government Life Annuity arrangements, the Colonial Office, our Foreign relations, the Exchequer Bill Office, the Victualling Department, the Board of Works, and the Railway Commission; but we are now enlightened as to the management of the dock yards and steam navy, the crown forests, the Money Order Office, the Mint, and the Ecclesiastical Commission. Those must be mad, indeed, who trust the government willingly with the management of anything.

As the grand features of government management are irresponsibility to the public and inaccessibility to individuals, and as these are the chief evils of the present water management, we may well hesitate when the transfer of powers is proposed. As, too, the management would be concentrated under the government without any corresponding advantages, the result might be an exchange of King Log for King Stork.

So far for public interests: and as for professional interests, the proposition of government administration bears with it no greater inducements. It is never the object of the government to employ talent; but to work their patronage for political purposes, resorting to talent only in the last emergency. This statement requires no comment, for its truth is within the experience of every one. Further, the government, wherever they can, avoid the employment of civil engineers, and employ military engineers, as the many distressed members of the profession in the metropolis know, to their sorrow. Whereas, in other countries, civil engineers and surveyors are employed to execute the general survey and *cadastre*, here, without any reason, such work is given to the Ordnance department. In the first new Commission of Sewers, not one civil engineer was named; and, in the following Commission, Messrs. Stephenson and Rendel are muzzled by twice the number of military engineers. It is no uncommon thing at the meetings of the Commissioners for no civil engineer to be present, or for one civil engineer to be present and three military engineers. Having seen these things, we do not advocate government management; while so far as we know, the City of London, the Old Sewers Commissioners, and paving boards, do not employ captains and lieutenants, but competent civil engineers and surveyors.

The profession have forced the government to do something to name civil engineers on the Sewers Commission and the National Exhibition Commission; and the wedge, having been thrust in, must be driven home.

As to mock public bodies under the name of independent trusts and boards, they are as bad as regular government commissions; and we may refer to the Old Commissioners of Sewers, the Trustees of the British Museum, the County Magistrates, the Moneyers of the Mint, and the Royal Academicians. These parties, unless it suits them, do not even acknowledge the jurisdiction of the legislature, while the assessments of the county rates and police rates are very unsatisfactory to the rate-payers, who have no remedy but to send deputations to Sir George Grey, which are not always received. A secretary of state is too great a man to listen to parish vestries.

No valid objection lies, so far as we know, to the management by the public of their own affairs. The City sewers and paving are quite as well managed as any; and it is to be presumed the constituency are satisfied, as they are not turning out their representatives, which they have the power to do when displeased. The government have likewise been forced to allow the citizens to be represented in the Metropolitan Commission of Sewers. If the government do not choose to give corporations to Marylebone and Lambeth, that is no reason why the inhabitants should be deprived of the control over their own interests, which is allowed to the inhabitants of Manchester and Birmingham, though neither of these had a corporation before the Municipal Reform Bill. No one will say that the people of Marylebone are less fit to manage their sewers and water supply than the people of Manchester, nor that there is any greater need for government tutelage of the former than of the latter. The people of Marylebone do not ask for government tutelage, but repudiate it, and do not offer to give up to the government the control over the poor, the paving and the gas companies.

Of course the government, whenever public management is talked of, have a holy horror of jobbing; nay, if they durst, they would cast the charge of jobbing in the teeth of the Corporation of London, and the Marylebone vestry. Perfect management can never be got from imperfect human nature, and therefore jobbing may be expected; but at any rate the citizens of London, the burgesses of Manchester, and the inhabitants of Marylebone, job with what is their own, for their own benefit; whereas the government job with what is ours, for their own benefit. There have been some pretty things done in corporations; but while Lord Monteagle, Lord Brougham, and Lord Ellenborough, sit in the House of Lords, the less that is said in high quarters about jobbing the better.

The election of a general Commission may take place either directly by the ratepayers, or indirectly by means of the boards of guardians. The latter way will do well enough for the present.

Instead of one central Commission, which cannot attend to the individual demands of two millions and a half of people, living in more than a quarter of a million of dwellings, we should prefer district Commissions with the power of uniting for any general purpose. To these we would commit the care of the sewers, street improvements, paving, cleansing, lighting, water, and turnpike roads.

Our reason for preferring district Commissions is, that the working of a Central Sewer Commission is not favourable to the plan of one Commission—while no general plan of drainage has been adopted, and no general measure has been carried out, the interests of localities have been neglected. Indeed, what care is likely to be taken of Poplar or Hatcham, by a board on which neither has a representative. Local interests are therefore left to the local officers, who become virtually irresponsible, and set the public at defiance. Poplar may be neglected that Westminster may have the first turn, or Lambeth be made to give way to Pimlico. In the City of London Commission, which exercises all the functions we have wished to see united, each locality has its representative; and the individual can, as he pleases, apply to his own representative, living in his own street, or to the whole court.

The system we have proposed will get rid of the confusion and expense of so many separate trusts as now exist, afford all the benefits of centralisation, and yet be perfectly accessible and amenable to public control,—while it will have a sufficiently permanent character. The system has worked well in the City of London, and there is no reason it should not work well throughout the metropolis.

Of course it is difficult arbitrarily to define new districts, but we think as far as possible the several natural water courses should form separate districts, and the line of division should be taken upon the water shed. The Lea, the Fleet, and the Bayswater brook districts, have few interests in common, and such as there are can readily be arranged by a convention or delegation of the several districts. If a new outfall is to be provided, or some new source for water, a delegation from the several Commissions can very well manage it, as the separate committees of one commission or corporation perform separate functions, so in the City, the Bridge Committee, the Improvements Committee, the Navigation Committee, and the Markets Committee.

Westminster and Marylebone might, we think, form one district, the line of water shed passing by Holborn-hill, and so by the west of the Fleet. The City of London would remain undisturbed. Finsbury or the Fleet valley might form a district, and the Tower Hamlets or the Lea another. On the south the Ravensbourne, Lambeth or the river marsh, and the Vauxhall brook might form the bases of other districts.

SUPPLY OF WATER TO THE METROPOLIS.

On the 4th of February, Mr. Tabberner gave a lecture to a very respectable audience, in Willis's Rooms, St. James's-square, "*On the Sources available for Improving the Supply of Water to the Metropolis.*" The Right Hon. Lord de Mauley presided, and several members of parliament and scientific gentlemen were also present.

Mr. Tabberner commenced his discourse by observing, that there was no necessity for his alluding to the great urgency of improving the water supply of the metropolis: the imperative necessity was universally admitted as the first step to be taken towards the attainment of any comprehensive sanitary ameliorations. Public opinion had very much changed within a short space of time, as to what was to be understood by a *good* supply of water. The quantity now estimated as absolutely essential for the social requirements of the inhabitants of all large towns had increased from 200 to 300 per cent. over the quantity deemed necessary some three or four years since. Without unnecessary preface to his object, he would therefore at once proceed to point out—first, the various means of improving the metropolitan supply afforded by the surface waters adjacent to London; secondly, he would enter into a geological explanation of the structure of the chalk stratum beneath and around London, and its capabilities of affording water to the inhabitants by means of Artesian wells, which he would illustrate by the several diagrams then before them; and, thirdly, expound the great benefits that will accrue to the public socially and fiscally, by consolidating the whole water supply of the metropolis, the drainage and sewerage, paving and lighting, and the regulations pertaining to the erection of metropolitan buildings, under one public commission, directly responsible to the inhabitants and the government conjointly. The lecturer then proceeded to say, that the surface waters available to London principally rose as springs from the chalk formation, by which the metropolis is surrounded, and extending under the alluvial deposits upon which it is built. If we took the south and east of London from the outsides of the inclinations of the chalk basin, we had the rivers Kennet, Loddon, Auborne, Wey, Mole, Wandle, Ravensbourne, and Cray; and on the west and north, the rivers Brent, Colne, Gade, Verulum, Lee, Stort, Ware, and Rodding—all of which took their rise as chalk springs, and grew into important streams and indirect tributaries of the river Thames: the latter taking its rise from several springs in Gloucestershire, and, as they were aware, grew into a navigable stream by the natural drainage of the country through which it wound its course to the metropolis. The quantity of wholesome water available from the above surface sources alone to the use of the London public, would amount to from 200 to 300 million gallons per diem.

The schemes now before the public for improving the general water supply, viz., the Wandle, the proposed improvement of the Lambeth Company's works, by taking their future supply from Thames Ditton; the Maidenhead, the Henley-on-Thames, the Mapledurham, and Watford schemes, were severally explained by Mr. Tabberner, who, of the Thames schemes, gave the preference to the Henley-on-Thames, in consequence of the confluence of the rivers Kennet, Lodden, and Auborne, just above the source of supply; and also because it proposed to place the whole water service under the control of a public commission. As to whether the quality of the water would continue permanently good, and as to whether the navigation of the river would be damaged by the proposed abstraction of 100 million gallons of water every 24 hours, were points to be decided. These, he said, were difficulties to be overcome, which would at least require skill and mature consideration; and concluded the first part of his discourse by explaining the late Mr. Telford's schemes, and the propositions made to improve the New River Company's and the East London Company's supplies, by taking the waters of the rivers Ware, Stort, and Rodding.

Mr. Tabberner then described the alluvial and chalk deposits upon which London was built, and proceeded to urge that the many statements which had gone forth to the public from Dr. Buckland, the Rev. Mr. Clutterbuck, Mr. Braithwaite, and others, were wrong with respect to the alleged failures of many of the commonly-called Artesian wells sunk in and around London—especially the theories of Mr. Clutterbuck. It had been stated that the Messrs. Barclays and Messrs. Calverts were now compelled to work alternate days on account of their interfering with each other's wells: there was not a particle of truth in such a statement. Originally, when both their wells were sunk only into the sand above the chalk, they undoubtedly did affect each other; but since Messrs. Barclay had sunk 153 feet into the chalk, they had had an uninterrupted supply of water. The quantity had, however, somewhat diminished since 1843, owing to a fact important to be known. When they first sunk the bore-pipe into the chalk, they at the same time continued to avail themselves of the water afforded in the sand, by perforating that portion of the pipe which passed through it; the sand had consequently percolated through those perforations with the water, and had precipitated down, and become consolidated in the pipe of the chalk to the extent of 73 feet, and had stopped the free passage of the water from the fissures of the chalk. A short time since the pipes had been cleaned out, and the water had since gradually risen. He had no doubt that many similar unascertained casualties existed. Mr. Tabberner then gave a description of the capabilities of the Trafalgar-square works, showing that when they were quite completed they would be able to afford from 1,000 to 1,200 gallons of water per minute, a supply which would be sufficient to furnish the Serpentine River, the Barracks round the parks and at the back of the National Gallery, the Fountains in Trafalgar-square, the Queen's Palaces, the Houses of Parliament, the whole of the Government Offices, the Baths and Wash-houses in St. Martin's-in-the-Fields, &c., at an annual charge of from 1,200*l.* to 1,500*l.* less than such a supply would cost if taken from the Chelsea Water Company. The whole outlay would be about 18,500*l.*, and the annual working expenses 1,000*l.* He further adduced many facts, showing, by carefully prepared diagrams of the principal deep wells, and of the sand and chalk strata, at what depths beneath the London clay an uninterrupted supply of water might be obtained, and where and how the elevations of the chalk beneath the clay interposed difficulties in obtaining a supply of water; clearly demonstrating that it was the water in the sand-bed above the chalk, and not the water in the depths of the chalk, that was limited in quantity; and describing how, from the declivity of the chalk formation, the fissures thereof under the alluvial deposits discharged the water into the sand; and how the wells sunk only into the sand were more or less subservient to each other.

A discussion here arose between Mr. BRAITHWAITE and the lecturer, the former endeavouring to prove that the increased quantity of water at Covent-garden market had been obtained by improving and lowering the pumps of the well, and not altogether by sinking the bore-pipe into the chalk.—Mr. Tabberner said he was not contending for the mechanical superiority of one engineer over another, but for the demonstration of the fact that for many years Mr. Braithwaite had been endeavouring to obtain a sufficient quantity of water for the market out of the sand-bed above the chalk, and that he had not succeeded. Messrs. Easton and Amos had subsequently bored 90 feet into the chalk, and thence obtained a bountiful supply of water. This instance, and many others which Mr. Tabberner adduced, showed that Mr. Braithwaite was wrong in his supposition that the principal body of water was to be found in the sand and not in the chalk.

Mr. CLARKE, who had bored a great number of wells in and around London, and who was then engaged in extending the boring of the Southampton deep well, here rose to support Mr. Tabberner's views. He had frequently bored considerable depths into the chalk without obtaining water; but by continuing to bore deeper he had always ultimately found an abundance of water.

Mr. TABBERNER then proceeded to describe the quality of the chalk water, showing that reports as to its hard and chalybeate qualities were not founded in truth. The carbonate of lime and magnesia, which were the hardening constituents, did not amount to 6 grains in the gallon, while the same constituents in the Thames water amounted to from 10 to 12 grains in the gallon. He further urged that the other properties contained in the chalk water were essentially wholesome, and necessary to the natural support of the human body. The rain as it fell on the exposed surface of the chalk was *pure* water; but as it percolated through the chalk fissures, it took up in its course, in a greater or less degree, the carbonate of lime, magnesia, the alkaline, and other constituents he had alluded to. He distinctly contradicted the groundless supposition that the sea water found its way into the deep wells of the chalk under London, and denounced the idea as a theory perfectly fallacious and untenable.

Mr. BRAITHWAITE here again denied Mr. Tabberner's last position to be correct, and gave Professor Brande as his authority. He said, all deep wells, the water of which did not rise to the level of Trinity low-water datum, were affected by the sea-water percolating into them, and instanced the deep wells at the Mint and Trafalgar-square respectively, as producing water so affected.—Mr. Tabberner took Mr. Braithwaite's own authority, Professor Brande; and from a paper of the latter lately published, showed that the solid contents found in the water of the well at the Mint, were 38 grains in the gallon; and that the solid contents found in the water at Trafalgar-square, were 68 grains in the gallon. He contended that Mr. Braithwaite was again in the wrong; the salt and alkaline properties of both wells differed in the same ratio, and there were no two wells alike. He, Mr. Tabberner, therefore submitted, whether, if both these wells—indeed all the deep wells—produced sea water, they would not be identical in their constituents: the fact of their not being so would not justify Professor Brande, Mr. Braithwaite, or any one else, in the supposition that the water in the deep wells, or what was commonly called Artesian wells, as sunk into the chalk formation under London, were impregnated with sea water.

Mr. CLARKE here said, that he had bored the well at the Mint, and that Professor Brande had told him that the water raised from it was very pure.

Captain MOORSOM asked Mr. Tabberner, whether it was not true that many of the London brewers had been in great difficulties with regard to their supply of water from the chalk; and if they had not been compelled to deepen their wells?

Mr. TABBERNER said they had, as he had already admitted; and it would be contrary to common-sense and the natural laws of hydraulics, to suppose that the level of the water of the chalk did not lower as the number of wells sunk into it increased. There was but an average of 21 inches of rain fell upon the chalk surface; and supposing only 10 inches of the whole quantity percolated through the fissures into the depths of the chalk, only that quantity could be found in it; and supposing that first 100 wells were sunk, then 200, then 500, and so on, it was very natural and a necessary deduction, that the original level of the water would be gradually lowered; but as the wells were deepened into the vale of the chalk formation, the water would be found in proportion to the depths in greater abundance, and the general level of the water contained in the fissures would vary according to the quantity of rain and snow falling on the exposed surface of the chalk; and in proportion to the quantity of rain so falling, repletion would be afforded to the wells—and he had no doubt in his own mind, that from 400 to 500 million gallons of water might be raised from the depths of the chalk stratum per diem. He estimated the cost of an Artesian plant, consisting of 100 wells and engine power, 1,200 miles of 7-inch main piping, and the contingencies pertaining to an undertaking competent to supply from 30 to 50 million gallons of water every 24 hours, at 1,700,000*l.* The annual cost of a continuous high and low service to every house, he estimated at about 70,000*l.*, or about 1¾*d.* per 1000 gallons.

Mr. TABBERNER concluded his lecture by a statistical exposition of the saving that might be effected to the public, by taking the water supply out of the hands of trading bodies, and hereafter placing it under the control and management of a public elective board, as public property, subjected to the supervision of government. He would first urge upon the government the necessity of introducing a measure into Parliament, which should provide for such a board, with powers to raise money upon the future rates, to be equally levied according to the assessment upon every house throughout the metropolis, the ground landlords being made liable for the rate, which liability should enjoin compulsory powers to extend the water supply to every house, and to make such supply a part and parcel of the fee-simple; while every site applied to future erections of any denomination whatever, should be chargeable with the cost of extension of water-service mains and pipes to such property as it was used for building purposes. He would then raise sufficient means to purchase the plants and interests of the existing companies, which he would turn to sanitary purposes, and provide an entire new continuous plant for domestic purposes, the whole cost of which he computed at about 4,500,000*l.*, which he stated might be raised without asking government or the ratepayers for one shilling, while the average rates might immediately be reduced very considerably. Thus would be restored to the inhabitants that indefeasible public right to this first necessity to man's subsistence, which was formerly enjoyed by the citizens of London prior to the corporation transferring that right to commercial speculators. Mr. Tabberner set forth his calculations in the following form:—The present population was 2,336,000; and dividing that number by 7 (the mean number of inhabitants, according to the Registrar-General's Report, to every house), the number of houses comprising the metropolis, would be 333,000 houses, or say, for the sake of round numbers, 330,000, to each of which he would supply an average of 175 gallons of water, or 25 gallons to each individual of a population of 2,336,000, every day, at an average annual cost of 8*s.* per house, estimating the cost of water (in accordance with the prime cost to the existing companies, and also of the proposed new schemes), at 1½*d.* per 1000 gallons.

	£
This average rate of 8*s.* upon 330,000 houses, would produce	133,000
To pay 4 per cent. on 4,500,000*l.*, he would require an additional average rate of 11*s.* 3*d.* on 330,000 houses, which would produce................	180,000
To raise a liquidating fund to pay off the 4,500,000*l.* borrowed over a term of 30 years, he would require a further average rate of 6*s.* 3*d.* on 330,000 houses, producing	100,000
Or a total average rate of 25*s.* 6*d.* per house, producing a gross annual revenue of	£413,000

This average rate of 25*s.* 6*d.* per house would be gradually reduced as the progress of annual liquidation went on, till the whole debt was discharged, and the whole water supply become free to the inhabitants at the mere cost of conveyance, which result, under good and economical management, would be accomplished in a much less term than 30 years.

The average rate for every house supplied by the present companies was, in the year 1833, 30*s.* 10½*d.*, 5*s.* 4½*d.* more than the total average required by Mr. Tabberner to accomplish all he proposes; and presuming that the average rate now charged by the companies is not less than it was in 1833, it will appear that the annual cost of the present water supply to only 259,668 houses (the number of water tenants given by Sir William Clay), is 391,124*l.* 18*s.* 6*d.*, or little under 22,000*l.* less than the annual revenue required by the lecturer to supply 330,000 houses, and to pay off all the sum required to afford an entire new service for domestic uses, and to purchase the plants of all the present companies for sanitary purposes.

Mr. **Tabberner** proposed, that the public commission under which this beneficial sanitary institution should be established, and by which it should be worked, should be composed of property-qualified ratepayers, four or six out of every electoral district, to be periodically elected—say one-third to retire every three years, and to be eligible to be re-elected; which commission should appoint an acting paid committee, not members of the commission, but practically-qualified men, as public servants,—which committee should be bound constantly to attend, and to devote the whole of their time to the business of the commission, aided by not more than two government inspectors, through whom the commission should be made responsible to government through the medium of the Board of Health: thus producing a power of control directly responsible to the inhabitants and to the government. And in addition to the water supply, he would place the control and management of the sewerage and drainage, paving and lighting, and the erection of metropolitan buildings, under one and the same commission; thereby secure efficiency, uniformity, and economy, and, he believed, in a very short space of time, an annual saving of the public funds of not less than 300,000*l.* He also suggested, that it would be well to make such a Bill as he proposed, compulsorily applicable to every town and city in the United Kingdom; each place to be divided into districts, and each commission to be elected in numbers according to the amount of population, and the whole also subjected to an inspection responsible to government through the medium of the general Board of Health.

REMARKS

ON THE PLAN PROPOSED BY THE

METROPOLITAN COMMISSIONERS OF SEWERS

FOR THE

DRAINAGE OF THE SURREY SIDE OF THE METROPOLIS.

> "At present there is a prevailing approach to agreement in the Sciences, founded on an observation of outward nature. When controversies arise in these Sciences, they are generally confined to limited questions, and to points upon which attention has been recently turned, and after a time they are settled by investigation and reasoning."—LEWIS. 'Essay on the Influence of Authority in matters of Opinion.'

> "It has been shown in matters of drainage, that the economy and efficiency of the works will be according to the qualifications, the powers, and the responibilities of the officers appointed to execute them, secured by legislative means; and that new labour on the old condition, without skill, will be executed in the old manner, extravagantly and inefficiently."—EDWIN CHADWICK. 'Report from the Poor Law Commissioners on the Sanitary Condition of the labouring population of Great Britain.' 1842.

At a meeting of the Members of the Metropolitan Sewers Commission, held at the Chief Office, Greek-street, Soho, on the 25th of January last, the following resolution was put from the chair by Sir Henry De la Beche, and carried:—

"That it be recommended to the court that the engineer be instructed to prepare estimates for the consideration of the Commissioners, for a plan of the drainage of the Surrey side of the Thames, with reference to a covered channel for general outfall, between Vauxhall and Deptford, or thereabouts, by which the present distance by the river will be shortened, and a better outfall secured; to the continuation of the channel to and beyond Woolwich, and to the removal of the whole sewage of such area from that part of the Thames, due attention having been had and being paid to those plans sent into this Commission which relate to the same area."

We may therefore shortly expect a detailed communication on the subject from Mr. Frank Forster; and as, in the event of his estimates being deemed satisfactory, there is not merely a possibility, but a probability, of the proposed scheme being carried into effect, we take an early opportunity of making a few brief observations on the merits of Captain Vetch's plan, which, we hope, will at least have the effect of directing the attention of the public to the necessity of mature consideration being given to so important a subject before any plan is finally adopted.

All we are in possession of as yet respecting the proposed plan for the drainage of the Surrey side of the metropolis, is principally contained in the reported speech of Sir Henry De la Beche, delivered at the meeting of the Commissioners above alluded to. We shall therefore confine ourselves strictly to the statements made by Sir Henry, and consider how far such statements are likely to lead us to hope for such effectual drainage of the south side of the river as the public have a right to expect from the Commissioners and their engineer.

It was with no small degree of satisfaction, after the published opinions of Sir John Burgoyne and others of the Commissioners, that we saw the report in the *Times*,[1] headed "Drainage of the Metropolis—*Purification of the Thames;*" and the opinions of Sir Henry respecting the importance of the non-pollution of the Thames fully stated. He concludes this important part of his address with the following sentence:—"Under all these points of view, it seemed essentially desirable that they (the Commissioners) should be instrumental in removing the sewage from the Thames." This is most satisfactory: it settles the important question—"Is the Thames to be polluted, or not?"—"No."

In considering the manner of draining a district, the matter of consideration that deserves our first attention is, that of a sufficient outfall; and the question naturally arises, what natural outfall or outfalls does the district and its neighbourhood afford? Of outfalls there are three different kinds: first, there are natural outfalls immediately connected with the district under consideration, which again divide themselves into available outfalls and unavailable outfalls, according to the conditions imposed on the engineer—viz., according to the object or objects, whether direct, indirect, or both, for which the drainage is contemplated. Secondly, natural outfalls, not immediately connected with the district to be drained, requiring an artificial conduit of communication between the area to be drained and that possessing the necessary sufficient outfall. Thirdly, artificial outfalls.—Let us consider the case in question. We have, in the first place, a natural outfall in the river Thames, encircling, as it does, nearly the whole of the western, northern, and eastern sides of the district. Is it an available outfall or not? That the Thames is not to be polluted by the admission of sewage matter into its stream, is at length acknowledged by the Commissioners themselves. "They," says Sir Henry De la Beche, "should recollect that the sewage, according as the population had increased, was more abundant in the Thames than formerly. Good as the 'flushing system' was in many points of view, it had added to this evil, inasmuch as the matter which was previously collected and removed by hand, was now thrown into the Thames. Another point to be considered was, that since the erection of London-bridge there was a difference of 3½ feet in the height of the water above the bridge, and which had been a source of considerable annoyance to the population." Under "all these points of view," adds Sir Henry, it seems "essentially desirable" that the Commissioners "should be instrumental in removing the sewage from the Thames." Under these considerations, the natural outfall of the district of Southwark becomes an unavailable outfall. But there are other reasons why the Thames should be rejected as a receptacle for the sewage of this portion of the metropolis. It is a tidal river, and portions of the district are below high-water mark; from which circumstance it follows, that whatever means be adopted for draining the said area, making use of the Thames for an outfall, the mode of operation must inevitably become intermittent instead of constant—the sewers and drains becoming cesspools during portions of each day. Moreover, the length of time during which, in such a case, the sewage would have to remain confined within the drains, would be in an inverse ratio with the inclinations, and, consequently, "effectiveness," as regards discharge, of the whole system of drains; or, in other words, according to the height of the cill of the outfall-end of the main sewer. It is true, that by proper trapping much of the evil attending an intermittent plan of draining can be remedied; but no system of sewerage can be deemed really good that is not constant. Well, then, the Commissioners have agreed most judiciously—not to say of necessity—not to make use of the only natural outfall presented by the district. Of neighbouring outfalls (the second class before alluded to) there are none at all available along the line of coast: artificial means, therefore, become indispensable.

Let us now examine the plan proposed by Captain Vetch, for the thorough drainage of the Surrey side of the river.

Sir Henry De la Beche began his observations to the Commissioners by calling to their recollection, that when they first took office under the present Commission, it was intimated to them that the subject of the drainage of the Surrey and Kent side of the river had received very considerable attention. "During the exi[illegible] the previous Commission," continues Sir Henry, "[illegible] committee, termed the 'Ordnance Survey Com-

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[1] [illegible]" of Saturday, January 26th.

mittee,' four members belonging to which were members of the present court. During this time the Ordnance Survey Committee had been engaged in that part of the metropolis, and were constructing the network of levels. It was thought to be extremely desirable that three or more points of the river should be connected with such levels, to ascertain the height of the tide. The result has been the production of a very valuable collection of facts and documents, from which it would appear that they should even think of constructing the lines and shortening the distance between Battersea and Deptford. The minimum difference in the tide between these places was 2½ feet. It was obvious that by shortening the distance they would accomplish a better fall, if that were needed." Sir Henry might well have saved himself the trouble of going into these details, since from his own statement, fully given, a fall of any kind into the Thames cannot only not be needed, but is of necessity to be avoided. But let us continue. Sir Henry "thought he might mention what was, no doubt, known to the Commissioners, that a valuable body of information was collected by Mr. Page, for the Metropolitan Improvement Commission, and which was printed in their reports. Part of it was original, and part contained in other documents, &c.; but he (Sir Henry) referred to it as embodying a mass of valuable matter." No doubt about it. "The attention of Captain Vetch had been especially directed to the formation of a scheme for the drainage of the Southwark side of the river Thames. He wished it to be particularly noted, that all this occurred previous to the former Commission requesting plans to be sent in for the drainage of the metropolis. With respect to the scheme for taking the shorter line on the north and south side of the river, and so partially reversing the drainage, in this there was no great novelty. So far as ten or eleven years ago, he believed that Mr. Thomas Cubitt had proposed a scheme of that kind, which was quoted by Mr. Walker, in his evidence in 1840, on the state of the Thames. This was not the first scheme which included the stopping of the drainage by the river, because Mr. John Martin had previously completed the scheme for drainage on both sides of the Thames. With regard to the south side, their object had been to obtain a fall by shortening the distance, and the opportunity of flushing the main channel and any branch channel, without, as now, discharging all the sewage into the Thames; and afterwards affording the opportunity of distributing the sewage manure by various lines of railway, as the wants of the public should demand, supposing the drainage should cut the lines of railway."

What are we to understand from all this? Sir Henry, in one part of his speech, most emphatically expresses his opinion as to the necessity of no longer polluting the bed of the river with the filthy discharge of any portion of the sewage of the metropolis; and in the next, advocates an outfall into the said river, because an "advantageous" additional fall of 2½ feet can be obtained by taking a shorter course. As to Sir Henry's statements respecting the evils attending the use of the Thames as an outfall for the sewage of London there can be but one opinion. The writer of a leading article in the *Times* of the 28th January last, observes, "In the first and foremost place, it [the resolution passed at the meeting] contains the deliberate acknowledgment of the Commissioners, that the river Thames should no longer be retained as the main sewer of the metropolis, but should be drained and cleansed like any other infected locality." And in order to effect this draining and cleansing of the bed of the river, it is now proposed to pour into its stream at Deptford, or may be Woolwich, at low water, all the refuse of the densely-populated district lying between Battersea and Deptford, that will not have been carried away by rail for agricultural purposes, "supposing the drainage should cut the lines of railway."[2]

Even admitting the extension of a conduit from Deptford to Woolwich,—and Sir Henry does not even allude to the subject in his speech,—and thereby the removal of the Southwark sewage beyond the boundary that divides Surrey from Kent, we need hardly add that the reasons for discontinuing the pollution of the Surrey and Middlesex banks of the river must surely apply equally powerfully to the Kent bank, bordering so densely populated a district as that lying between Deptford and Woolwich; particularly when we take into consideration that a discharge of sewage, wherever made on the south side of the river, has to meet with the influence of an *up*-tide, consequent on such discharge taking place inevitably, on account of the lowness of the district, at low water. Sir Henry, who had occasion some years ago, he tells us, to consider the distribution of sewage into estuaries, and who agrees with Sir John Burgoyne, "that the Thames being an estuary, all the effects that take place in an estuary must occur in it also," will o course understand most readily the results which we are likely to anticipate from a removal of the refuse of Southwark into the bed of the Thames, whether at Deptford or Woolwich, at low water;[3] and from the action of an up-tide, immediately after its discharge. We cannot do better than borrow Sir Henry's own words. "The sewers discharged their contents into the Thames at low water; at that time the water being stagnant, the sewage was discharged into the river according to its velocity, but on the first motion of the water, it (the sewage) had a tendency to go along both sides of the river, and two masses of filth were thus trailed along the banks. This was composed of matter in chymical solution, and mechanical suspension. Now these two masses passed along both shores and went as far as the tide would carry them."[4] This is precisely what takes place; and in the case before us proposed by Sir Henry, the sewage of a large and populous district will be discharged into the Thames at Deptford, at low water, according to its velocity: the water in the river at the time being stagnant. On the first motion of the water, it (the sewage) will have a tendency to go along both sides of the river, and two masses of filth will thus be trailed along both banks. This will be composed of matter in chymical solution, and mechanical suspension. And these two masses will pass along both shores and will go as far up the river as the tide will carry them—and we may add, taking the more populated and important part of the metropolis on their way.

In addition to this, we find that the Thames is not only to be polluted with the discharge of the Southwark sewage, but that at a meeting of the Commissioners on Friday, the 8th inst., a sewer through a considerable portion of Westminster, discharging itself into the Thames, was determined upon, on the recommendation of Mr. Frank Forster, and is about to be carried into effect.[5] So much for the statements of Sir Henry De la Beche, as to the general wish of the Commissioners not to pollute the Thames with sewage matter. The writer in the *Times*, already quoted, hoped for better things when he wrote:—"Our very words are now almost snatched from our mouths by these eager converts. 'There is no reason,' says the Chairman, 'why artificial means should be adopted to add to the noxious qualities of the river mud.' None in the world, certainly.—'It gets moistened with the sewage matter, and that adds to the disagreeableness of the filth.' Not a doubt about it.—'Looking on shore, too, this deposit is sure to be discovered in situations most inconvenient to the inhabitants.' Of course it is. As the American engineer said, 'It seems to take a pleasur' in gettin' there.'—All these are axioms, if of a somewhat elementary, yet of a most unquestionable character, and we are only too glad to see them at length formally recorded." Yes "recorded"—and that is all.

"But," it might be argued, "it is not the intention of Captain Vetch and the Commissioners to make use of the proposed outfall exclusively for the purpose of a means of discharge into the Thames: they hope the demand for liquid manure will be such as to prevent almost entirely the pollution of the river." If so, we can see no necessity for the expense of a main sewer from Battersea to Deptford, with a continuation to Woolwich—no small amount of work to execute. For the purpose of transport into the country, mechanical means of some kind must be employed for raising the diluted refuse from the low levels at which it will be confined, whether the principal outfall be at Deptford, Woolwich, or elsewhere; and surely there can be no kind of apology for wasting the public money in constructing expensive works, from which no advantage can possibly result, that could not be obtained for a far less sum, without such a main sewer. If the Thames is really to be rejected as an outfall, an artificial outfall becomes

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[2] Purely conditional on accidental circumstances.

[3] And if we take into consideration the depth of some of the basement stories in some of the lowest parts of the district, in connection with the question of sufficient fall for branch drains, we think Mr. Forster will not find low water mark at Deptford much too low for the invert of his sewer.

[4] "Nothing could be more beautifully expressive than this description. To be sure it was somewhat superfluous, and resembles a little that technical certificate of Death's doings which the medical witness offers to a coroner's jury:—Deceased having been found hanging, it is proved that the articulation of the cervix with the occiput has been disordered, and that great extravasation is discoverable in the brain,—facts, doubtless of great importance, but not adding much to the convictions of those who had cut the poor wretch down, stone dead. We citizens can see but too plainly how the sewage hugs our banks, and are perfectly willing to believe that the result is in accordance with the eternal laws of an estuary. All we ask is a verdict in our favour."—"Times," of Monday, January 28th.

[5] Let the rate-payers look to the new Westminster sewer. It cannot be an inexpensive work, and it is sure to be either a superfluous or an inconvenient one. We admit that such accommodation cannot be delayed until the present problem is solved; but all this expenditure for provisional convenience will become little more than a dead loss when the entire system of sewerage is re-modelled. It is clear enough that we cannot cleanse the Thames in a day, but it is surely time to cease paying our thousands of pounds in order to vitiate it more thoroughly."—Conclusion of a leading article in the "Times," of Saturday, February 16th.

indispensable; and consequently there can be no possible use for a main sewer such as the one proposed. A great objection to what are called first-class sewers, too, is their great size, which renders them as inefficient as they are expensive. A well matured system of drainage should be properly graduated for the effectual removal of all refuse matters under well calculated, mean ordinary circumstances; and for all other cases, such as those of extraordinary floods, other means of removal should be provided, since no same sewer can possibly be made to act with maximum efficacy under the very dissimilar cases of limited or ordinary, and extraordinary discharge. And surely of the two, we should give the preference to efficacy under usual conditions of supply. To wish therefore to build sewers large enough under any circumstances, not only shows a complete ignorance of the first laws of hydraulic science, but argues a want of common-sense on the part of the projector. What—if we were to object to the human organisation, on the ground that the digestive organs merely provide for the digestion of the ordinary amount of food necessary for the purposes of life, on the score of the inconvenience attending indigestion, caused by no provision having been made in cases of surfeit of food—of extraordinary "feeds"? Our metropolitan sewers have been constructed capacious enough for all possible cases of indigestion; but, unfortunately, the gastric juice required—hydraulic pressure, —has been found to lessen with the increase of their sectional areas; deposits have taken place—accumulations of solid filth have blocked them up—the whole fabric has been found not only ineffective, but a public nuisance, alike dangerous to the health and morals of a large portion of the population.—What the remedy? Scouring.—The consequence? A series of intermittent cesspools. And is such a system still to be carried on? The public money expended in creating a still greater number of longitudinal receptacles for filth? We hope not. We would lay down as a rule that the minimum sufficient drain, for all ordinary purposes, whatever its class, is the one that should of necessity, on the mere principles of economy and common-sense, be adopted. We do not presume to settle the questions what the sizes of minimum sufficient drains should be under various circumstances, and for the different classes of house, street, court, and main drainage; but this we wish to be understood clearly, that, until minimum sufficient drains are adopted, maximum hydraulic pressure cannot be obtained—and unless maximum hydraulic pressure be obtained, maximum scouring-power and efficacy cannot possibly be realised.

Mr. Rendel, in his address to the Board, after seconding the motion made by Sir Henry De la Beche, said: "He had no doubt that when practical engineers were put upon the Board, something practical was intended should be done. He believed something practical would be done from the present time, and he thought that while acting so, they would have the public with them." We may be allowed to observe to Mr. Rendel that the putting of practical engineers upon the board, was no kind of reason for at all concluding or believing that something effectual and satisfactory, as well as practical, would be done in the matter of the drainage of the metropolis. Something "practical" was done, when practical engineers were consulted and employed to construct the various sewers now existing,—something "practical" was done when some of the leading practical engineers of the day were asked to report on the efficacy of these existing sewers—when they perambulated them, where possible—and expressed themselves fully satisfied! But unfortunately the "practice" in matters of drainage, which has prevailed in England up to the present time, is proved to have been most defective and unsatisfactory. The actual state of the drainage of London, after the enormous sums that have been expended upon it, is a sufficient warranty of the ignorance of our practical engineers respecting the principles that ought to have guided them in the framing of plans for actual execution. The Sanitary Commissioners express themselves on this subject, in the following words:—"The more the investigation advances, the more it is apparent that the progressive improvements and proper execution of this class of public works, together with the appliances of hydraulic engineering, cannot be reasonably expected to be dealt with incidentally or collaterally to ordinary occupation, or even to connected professional pursuits, but *require a degree of special study which not only place them beyond the sphere of the discussion of popular administrative bodies, but beyond that of ordinary professional engineering and architectural practice.* In justification of this conclusion, and to show the evil of the perverted application of names of high general professional authority, we might adduce examples of the most defective works, which have received their sanction."[6]

And further, "It will be evident to any one who has followed the course of the inquiries relating to Public Health works, that the principles that have been established for future operations will render inapplicable much of the experience that has been formed in the execution of works of house, street, and land drainage, water supply, and general cleansing."[7]

However precise and satisfactory the present state of hydrostatical engineering (and no better proof of the satisfactory state of this branch of science need be adduced than the success Mr. Rendel himself has met with, in the construction of some of the most important dock-works connected with this country; we may also instance the lifting of the tubes of the Britannia Bridge by hydrostatic pressure), the branch to which draining essentially belongs—hydrodynamical engineering—is as yet completely in its infancy, and little help can be derived from the "experience" of past ages. Bulky and numerous as are the writers, both English and foreign, on hydraulics, little or nothing, as yet, is known of the principles which regulate the flow of fluids. The great Newton himself failed[8] to grapple with this truly intricate subject. He invented the method of Fluxions, which enabled him to establish a theory of lunar motions; but he found himself reluctantly obliged to rest satisfied with a mere approximation, instead of a complete solution, respecting the motion of three bodies mutually influencing one another; and this convinced him how hopeless was the chance of ever accurately investigating the laws that regulate the motions of fluids where innumerable atoms comprise their respective influences on each other. "Newton," says Professor Whewell, in his 'History of the Inductive Sciences,' "treated the subject theoretically in the 'Principia;' but we must allow, as Lagrange says, that this is the least satisfactory passage of that great work." Formulæ, to be depended upon for future works of drainage, must be deduced from correct experiments. No data of value can possibly be obtained, but from thoroughly checked tables of correct trials; and upon correct practical results only ought we to depend for the framing of formulæ to work with.[9] Experiments on the flow of water through tubes, have, we believe, been carried on by order of the Commissioners. This is a step in the right direction. The practice which will have to guide us must be founded on such experiments, and we have little to expect from the mere past experience of our practical men; indeed we should rather shun the prejudices which generally accompany the constant treading in the same beaten path.

We have a new field open to us, with great difficulties to contend with, for as yet we have neither theory nor practice to guide us. Our theory has to be founded on correct experiments: our practice on correct theory. Sir John Herschell expresses himself with his usual clearness and simplicity on the subject: "It is a remarkable and happy fact, that the shortest and most direct of all inductions should be, that which has led at once, and almost by a single step, to the highest of all natural laws—we mean those of motion and force. Nothing can be more simple, precise, and general than the enunciation of these laws; and their application to particular facts in the descending or deductive method, is limited by nothing but the limited extent of our mathematics. It would seem, then, that dynamical science were taken thenceforward out of the pale of induction, and transformed into a matter of absolute *à priori* reasoning, as much as geometry; and so it would be, were our mathematics perfect and all the data known. Unhappily, the first is so far from being the case, that in many of the most interesting branches of dynamical inquiry, they leave us completely at a loss. *In what relates to the motions of fluids, for instance, this is severely felt.* We can include our problems, it is true, in algebraical equations, and we can demonstrate that they contain the solutions; but the equations themselves are so intractable, and present such insuperable difficulties, that they often leave us quite as much in the dark as before. But even were these difficulties overcome, recourse to experience must still be had to establish the *data* on which particular applications are to depend; and although mathematical analysis affords very powerful means of representing in general terms the data of any proposed case, and afterwards, by comparison of its results with fact, determining what those data must be to explain the observed phenomena, still, in any mode of considering the matters, an appeal to experience in every particular instance of application is unavoidable, even when the general principles are regarded as sufficiently established without it. *Now, in all such cases of difficulty, we must recur to our inductive*

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[6] 1st Report of the Met. San. Comm., p. 5.

[7] Circular Letter to Candidates for Inspectorships, p. 2.

[8] Principia, Book 2. Prop. 37, 1st Edit., 1687, and the 2nd Edition of 1714, which contains Newton's altered treatment of the subject.

[9] "The science of the motions of fluids, unlike all other primary departments of mechanics, is a subject on which we still need experiments to point out the fundamental principles."—Whewell.

processes, and regard the branches of dynamical sciences, where this takes place, as purely experimental. By this we gain an immense advantage,—viz., that in all those points of them where the abstract dynamical principles *do* afford distinct conclusions, we obtain verifications for our inductions of the highest and finest possible kind. When we work our way up inductively to one of these results, we cannot help feeling the strongest assurance of the validity of the induction. *The necessity of this appeal to experiment, in everything relating to the motions of fluids on the large scale, has long been felt.*"

We have thought proper to enter thus fully on the actual state of hydrodynamical engineering in connection with its own particular branch—the drainage of towns, and the little reliance to be placed, henceforth, in the experience and practice which has produced the defects in, and evils of, the present existing works; and which it is the business of the Metropolitan Commissioners of Sewers to remedy, because we find there is a leaning on the part of the "practical men" Mr. Rendel alludes to, to continue pursuing the old track. "For his (Mr. Rendel's) own part, he felt he could go with the opinion as to avoiding drainage into the Thames, *as far as it could be avoided, in reference to obvious and practical conclusions.*[10] He did not go one jot further; therefore while he went to the full extent of desiring to purge the Thames from the sewage of London, he must be certain that when the plan was carried out, that result would be obtained.[11] He believed, that the plan they had to-day before them, would go a great way in furthering this object; it would, at all events, be a step in the right direction." And yet it is an imperfect plan on the old intermittent principle, with a fall into that river, of whose purification we have heard so much stated by the Commissioners. Though unsatisfactory, our present knowledge and practice in matters of town drainage, we would still add, with the writer in the *Times*, already quoted:—"If the science and resources of the 19th century are incompetent to effect the drainage of the metropolis, otherwise than by its river, *so it must be; but let us ascertain the necessity, before we put up with its consequences.*"

In conclusion, the plan proposed appears to us defective,—

Because the sewage of the whole portion of the metropolis, lying south of the Thames, is to be poured into the river, thereby polluting it, at one of two highly-peopled districts; and

Because this discharge taking place at low water, involves the consequences attending the effects of an up-tide thereon;

Because a provision being made for flushing the branch-drains, implies the possibility of periodical cesspools;

Because the provision for flushing the main sewer, implies the intermittent instead of the constant system of draining;

Because of the impropriety of "flushing" manure already sufficiently diluted with an ample supply of water;

Because in the event of the sewage of the district being required for agricultural purposes, the main sewer from Battersea to Deptford, and its continuation to Woolwich, becomes a waste expenditure;

Because of the expense attending such a scheme.

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[10] "We readily accept the condition, and consent to ask for nothing impossible."—Leading article of the "Times," Monday, January 28th.

[11] "When we advocate the purification of the Thames, it is with the same 'sine qua non' as that alleged by Mr. Rendel, 'that the result,' namely, 'should be really obtained.'"—"Times," January 28th.

WELL WATER.

Analysis of the Well Water at the Royal Mint, with some Remarks on the Waters of the London Wells. By Professor BRANDE, F.R.S., V.P.C.S., &c. (Extracted from a paper read before the Chemical Society of London.)

In consequence of the defective supply of water at the Mint, Professor Brande was consulted on the best mode of obtaining a necessary supply of pure water for that establishment. He was authorised by the master of the Mint to consult with Mr. Thomas Clark, an experienced well-engineer, in reference to the subject; and accordingly desired him to examine into the condition and capabilities of all the wells, shafts, and tunnels, connected with the supplies of water throughout the building. This examination was carefully and effectually accomplished, and it appeared that the several wells were in a very dilapidated, and some of them in a very dangerous state: that few of them were so situated or conditioned as to admit of being sufficiently or safely deepened, so as to yield an adequate supply of water; and that, as respected the wells in the several engine-houses, they were mere reservoirs connected with the tunnel-shaft from the tower, and therefore almost exclusively supplied from the muddy source of the Tower moat.

Having personally convinced himself of the correctness of this report, and having had Mr. Clark's statement corroborated by Mr. George Rennie, he represented the matter in detail to the master of the Mint, and suggested three plans for consideration, namely:—

1. To derive the requisite supplies of water from the water companies.—2. To repair the present wells, and to deepen such of them as would admit of that operation.—3. To sink an entirely new well.

Professor Brande strongly urged the adoption of the latter alternative, which after due consideration, was agreed to. He therefore obtained proper plans and estimates from Mr. Clark, which after having been submitted to the Board of Works, and by their direction to Major Jebb, were ultimately ordered to be carried into execution.

It may be right to premise, that the total depth of this new well is about 426 feet; that the depth from the surface down to the chalk is about 224 feet, and the borings into the chalk about 202 feet; the following being the well-sinker's account of the strata gone through, namely:—

	Feet.
Made earth	11
Gravel and sand (with water)	13
Blue clay, with a few sandy veins (no water)	93
Coloured sand and pebbles (abundance of water)	14
Dark sand, with veins of clay (little water)	4
Mottled clay (dry)	6
Loamy sand and dark clay (little water)	5
Blue clay, with shells	6
White rock (quite dry)	3
Green sandy rock and pebbles (dry)	8
Loamy green sand and black pebbles (little water)	5
Green sand and pebbles (abundance of water)	6
Dark sand, with shells	40
Flints	10
Chalk	202
	426

The lining of the upper part of the well through the gravel and into the blue clay, is composed of stout cast-iron cylinders, 1½-inch thick, and eight feet clear diameter; they are made in five feet lengths, with internal flanges three inches wide, packed and jointed with strong bolts and nuts; these prevent all access of the land springs from above. The shaft is then steined to the depth of 88 feet (that is, nearly through the blue clay,) in 9-inch cemented brickwork; after which, cast-iron cylinders are resumed of seven feet diameter, and these are continued down to the chalk; but after passing through the stratum of mottled clay, they include a series of cylinders of six feet diameter, the space between the outer and inner cylinders being filled with gravel-pebbles; a bore-pipe, 20 inches diameter, and 45 feet long, is then driven to about ten feet into the chalk, and through this the boring is continued by an 18-inch auger, to the entire depth of the well. This well, and all the works connected with it, were completed at Christmas, 1846; and on the 1st of January, 1847, the whole of the works of the Mint, and the dwelling houses, were supplied with the water, which is raised in a six-inch main to a height of 50 feet above the surface, or 130 feet above the average level of the water in the well, and is delivered at the rate of 240 gallons per minute, by means of three pumps of 9-inch diameter, and 8-inch stroke, into a tank supported upon a building of brickwork. This tank is 100 feet long, 30 wide, and 5 deep; it contains, therefore, 13,000 cubic feet of water, or 93,750 imperial gallons. Two six-inch cast-iron mains, furnished with proper slide-valves, descend from this tank, one passing on either side of the Mint, so as conveniently to supply the whole of the establishment, the daily consumption of the water frequently exceeding 40,000 gallons; besides which a daily supply of 6,000 gallons is delivered, by means of a main laid from the Mint, across Tower-hill to the Tower, for the use of the inhabitants and the garrison, there being at present no serviceable wells in that fortress, and the water derived from the adjacent river being objectionable in point of cleanliness. The average height which the water attains in the shaft of the Mint well is 80 feet from the surface. After a day's pumping it is lowered, upon an average, 20 feet, but there it remains stationary, the flow of water from below maintaining the level, or in other words, delivering at the rate of about 240 gallons per minute. Before this well was completed, and before the boring into the chalk had been accomplished, the water derived from it contained 44 grains of dry saline matter in the imperial gallon. At present, the machinery being complete, and the well in full and daily use, the mean of several experiments in reference to the solid matter contained in the imperial gallon of the water, amounts to 37·5 grains. The substances contained in each gallon of the water are as follows:—

Sulphuric acid	7·44
Chlorine	6·31
Carbonic acid (after boiling)	5·84
Silica	0·50
Sodium (combined with chlorine)	4·22
Soda (combined with sulphuric and carbonic acids)	10·82
Lime	1·96
Magnesia	0·71
Organic matter Phosphoric acid Iron	Traces.

The water evaporated to one-fifth of its bulk, and filtered, had lost almost every trace of lime and of magnesia, so that it is probable that the greater part of these substances were held in the state of *carbonates*, by excess of carbonic acid. The carbonate of lime forms films during boiling, which subside, and appear under the microscope in the form of very minute acicular crystals. The crystalline deposit obtained by slowly evaporating the water after the precipitated carbonate of lime has been separated by filtration, exhibits under the microscope, three distinct forms—namely, cubes (of chloride of sodium), prisms, which lie distinct upon the other salts, and are efflorescent, sulphate of soda); and small aggregates of rhomboids intermixed with small spherical particles, like pin-heads (carbonate of soda). The residue of the evaporation of the water, after having been gradually raised to a dull red heat, acquired a grey tint, and exhaled a slight odour of burning azotized matter; and a piece of moistened turmeric paper held in the evolved vapour, was transitorily reddened.

Professor Brande had not been able to detect any potassa in this water; and only a slight indication of the presence of a phosphate, in the precipitate deposited by the water during boiling.

Upon the whole, he is inclined to regard the following as a tolerably correct statement of the proximate saline components of this water:—

	Grains in the Imperial gallon.
Chloride of sodium	10·53
Sulphate of soda	13·14
Carbonate of soda	8·63
Carbonate of lime	3·50
Carbonate of magnesia	1·50
Silica	0·50
Organic matter Iron Phosphoric acid	Traces.

The specific gravity of the water at 55° is 10007. Its gaseous contents he has not ascertained.

Mr. Brande concluded his paper by giving a short comparative table, of the relative quantity of solid matter contained in river and spring waters as have been carefully analysed. The wells which are termed *deep*, derive their water from the strata below the blue clay, and some of them penetrate into the chalk; those termed *shallow*, are supplied from the strata above the blue clay. This is the case with most of the common London wells, which, however, are often steined to a considerable depth in the clay, for the purpose of forming a reservoir.

		Solid matter in imp. gallon.
Thames at Greenwich		27·9
„ London		28·0
„ Westminster		24·6
„ Brentford		19·2
„ Twickenham		22·4
„ Teddington		17·4
Average of the Thames between Teddington and Greenwich		23·2
New River		19·2
Colne		21·3
Lea		23·7
Ravensbourne, at Deptford		20·0
Combe and Delafield's brewery, Long Acre	deep well	56·8
Apothecaries' Hall, Blackfriars	„	45·0
Notting-hill	„	60·6
Royal Mint	„	87·8
Hampstead Waterworks	„	40·0
Berkeley-square	„	60·0
Tilbury Fort	„	75·0
Goding's brewery, Lambeth	„	50·0
„ „ „	shallow well	110·0
More's brewery, Old-street	deep well	88·9
„ „ „	shallow well	110·0
Trafalgar-square fountains	deep well	68·9
Well in St. Paul's Churchyard		75·0
„ Bream's-buildings		115·0
„ St. Giles, Holborn		105·0
„ St. Martin's, Charing-cross		95·0
„ Postern-row, Tower		88·0
Artesian well at Grenelle, Paris		9·86

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Jan. 21.—Earl De Grey, President, in the Chair.

Earl De Grey informed the meeting that the Council, considering that much important information was contained in the Report and Evidence on Iron, equally applicable to architectural as to engineering purposes, had referred those volumes to the Committee on scientific experiments and investigations, for the purpose of examining and reporting thereon.

The President also communicated to the members, in reference to the Commission for the Exhibition of Works of Industry of all Nations, in 1851, that he had been officially applied to, doubtless with the sanction of her Majesty and Prince Albert, to be a member of that commission; but that he had been obliged to decline the honour on account of his health not permitting him to devote that attention, which would be required by the probably arduous duties of that commission. His lordship had no doubt, that the profession would be adequately represented by Mr. Barry, a fellow of the Institute, who had been appointed on the commission.

Mr. Bellamy, V.P., called the attention to an invention by Mr. Thomas Melling, by which the sashes of a window, instead of being lowered and raised, as at present, by lines, weights, and pulleys, acted by means of a rack, so that one sash served as a counterpoise to the other. Some observations were made thereon by the President and Members, and Mr. Melling was advised to render his useful invention still more practically available, by enabling only one sash to be opened at a time, instead of both at once, as requisite according to his present method.

A paper by Mr. Roberts, Fellow, was read, "*On the Arrangements and Construction of the Dwellings of the Labouring Classes*," which will be given in full next month.

INSTITUTION OF CIVIL ENGINEERS.

Jan. 29.—William Cubitt, Esq., President, in the Chair.

The discussion was renewed on the Rev. J. C. Clutterbuck's paper "*On the Altenations and Depressions in the Chalk Water Level under London.*"

It was contended, that the water in the upper districts of the chalk accumulated in a proportion increasing with the distance from the river or vent, and fell off, in a corresponding ratio, during its periodical exhaustion, which usually took place between April and November of each year. This alternation of level, which in the upper districts exceeded fifty feet in perpendicular height, would be represented by a line from the lowest vent, rising at an angle to the highest point saturated with infiltrated water. This had been proved by constant observation on wells, at given periods, throughout a certain district; all the springs forming the river proceeded from that source. From these and other positions it was argued, that if water be discharged from a shaft in the chalk, by a power not capable of entirely exhausting it, the rapidity of the reduction of the level would gradually decrease, until it was exactly balanced by that of the supply. This would naturally produce a gradually-extending depression of the water in the strata for some distance around; and it was shown to have been the effect produced, by pumping from an experimental well in Bushey Meadows, in August and September, 1840.

It was urged, that the real question to be determined was, whether a supply of water for London could be obtained from the deep springs in the sand or chalk. Sections and diagrams were exhibited, to show, by the former, that the supposed basin under London, was not as had been shown by geologists; and by the latter, that from July, 1837, to December, 1849, there had been a gradual depression of full fifty feet in the water of the sand-springs under London; and in consequence of this serious action, several of the wells had become tidal in some localities, and the water was rendered saline.

The Railway Board.—The attention of the members was directed to a serious case of legislative interference, whereby the free exercise of the professional skill of the Institution was now unwarrantably trammelled, and the public service materially interfered with. The introduction of wrought iron instead of cast iron, into railway bridges, was a recent invention of great value, and of which the most celebrated examples were the Conway and Britannia bridges. The same executive authority which had pronounced the erection of these two bridges to be impracticable, had recently declared, that a railway bridge constructed on a similar principle, and of identical materials, was insufficient in strength, although it was much stronger, in proportion to its possible load, than either the Conway or the Britannia, and infinitely stronger than any of the cast iron girder bridges which had for years adequately performed the public service, and had been by the same authority pronounced to be perfectly safe. The public had thus already been for a month deprived of the use of an important line of railway, by the application of an antiquated formula to a modern invention. For these cogent reasons, it was considered that the members had a right to request the interference of the Council, on the behalf of the profession at large; and they were urged to take such steps as appeared desirable for allowing the free development of engineering talent; and in the words of the Report of a recent Royal Commission, removing from "a subject yet so novel and so rapidly progressive any legislative enactments, with respect to the forms and proportions of the iron structures" of railways, which could not fail to be "highly inexpedient."—This proposition was received with acclamation.

Mr. Evan Hopkins's great Geological Sections of the Three Branches of the Andes were exhibited in the library. They showed about 260 miles from west to east, from Choco to the River Meta, in the eastern flanks of the eastern branch of the Andes.

Feb. 5.—James Simpson, Esq., V.P., in the Chair.

The discussion was renewed on the Rev. Mr. Clutterbuck's paper, and was continued throughout the meeting, so that no original communication could be read.

It was contended, that the area of the chalk district, subject to infiltration, for the supply of the springs and streams uniting in the basin of the Colne, could not possibly exceed the original published estimate of 113½ square miles, and that the proportion of water filtrating through, for that purpose, was much less than had ever hitherto been estimated, inasmuch as records by Mr. Dickinson's gauge was to a much greater amount than those afforded by the gauges kept by other experimenters.

It was also contended, that the original position assumed in the paper, had not been weakened by the subsequent discussion; that the observations of the chemists had tended to confirm the statement of the probability of an infiltration of water from the Thames. The practical conclusion to be drawn from the observations, recorded in the author's several papers were:—That the natural drainage and replenishment of the chalk stratum might be traced and accounted for, by observing the alternation of level, in various localities, and at different seasons. That any large quantity of water abstracted from the chalk stratum, at any given point, caused a depression of level around the point of such abstraction. That in the upper district any such abstraction of water would interfere with, and diminish the supply of, the streams, by which the drainage of the district was regulated; and lastly, that the depression of level under London, by pumping from Artesian wells, had proved that the rapidity of demand already exceeded that of the supply; and that any attempt to draw a large additional quantity for public use, would be attended with disastrous consequences.

It was suggested that, considering the great works of drainage and water supply which were in contemplation for the metropolis, and looking to the essential importance of having accurate and authentic geological information, in order that those great works might be executed on a sound and certain basis, that the geological survey now being carried on by government, in a remote district of North Wales, where no urgent need existed for early geological information, and where no new works of paramount importance were in progress, or in contemplation, should be transferred at once to the metropolitan districts, with a view to throw light on the real structure, mechanical and chemical, of the deep water-bearing strata, on which opinions so varying and so conflicting had been advanced.

An inquiry was made whether any steps had been taken by the council, in consequence of the statement submitted at the meeting of January 29th, urging the consideration of the manner in which the interests of the public at large, and of the profession were likely to be affected by the attitude recently assumed by the Railway Commission, in reference to the strength of the wrought-iron bridges used on railways.—It was stated that the council had not as yet taken any decided steps in the matter, but that a course had been suggested which, being followed, would most probably lead to satisfactory results. After this assurance the members expressed their confidence of the interests of the profession being in safe hands, and that every step would be taken for insuring their position and professional reputation.

The motion which had been prepared was therefore withdrawn; and the Chairman requested any communications on the subject to be made in writing to the Secretary, who would lay them before the council.

Feb. 12.—The first paper read was, *"An Account of the Cast-Iron Lighthouse Tower on Gibb's Hill, in the Bermudas."* By Mr. P. Paterson.

The site chosen for this tower was in latitude 32° 14′ N., and longitude 64° 50′ W., being the southern part of the Bermudas, at which point they are most safely approached. It was at first determined to construct the tower with the materials found in the islands; but, after some progress had been made in quarrying and dressing the stone, it was ascertained to be of too friable a nature for the purpose, so that the Home Government instructed Mr. Alexander Gordon, M. Inst. C. E., to prepare a design for a cast-iron tower, similar to that which had been erected from his designs at Morant Point, Jamaica, and which had proved very successful. The form of this tower was that of a strong conoidal figure, 105 feet 9 inches in height, terminated at the top by an inverted conoidal figure, 4 feet high, in lieu of a capital; its extreme outside diameter was 24 feet, at the narrowest part 14 feet, and at the top 20 feet. The external shell was constructed of one hundred and thirty-five concentric cast-iron plates, having inside flanges, and varying in thickness from one inch at the base to about three quarters of an inch at the top. In the centre of the tower there was a hollow cast-iron column, eighteen inches in diameter in the inside, and of three-quarter inch metal, for supporting Fresnel's dioptric apparatus, and in which the revolving weight descended; it was also used, in the daytime, for raising and lowering of stores, and likewise contained the waste water-pipe. The lower part of the tower was filled with concrete, leaving a well, faced with brickwork, about eight feet in diameter, and twenty feet in depth, in the centre. Above this were the seven floors, the two lower ones being lined with brickwork, and used as store rooms; and the upper ones, lined with sheet iron, were used as living rooms for the light-keeper. The details were then given of the mode of constructing the floors, the windows, the staircases, and of attaching the lantern and light-room to the main structure; it was stated, that the light was visible from all points of the compass, excepting when obscured by the high land between Gibb's Hill and Castle Harbour, from the deck of a vessel at a distance of about twenty-seven miles, and possibly at a still greater distance. The structure occupied less than one year in its actual erection, the different parts having been landed about the end of November, 1844, the first plate being erected on Gibb's Hill on the 19th of December, 1844, and the last plate of the tower on the 9th of October, 1845. The whole cost of the structure, including the lantern and light apparatus, was stated to have been about 7,690*l.*, and the annual expense of maintaining it, about 450*l.*

The next paper read was, *"A Description of Sir George Cayley's Hot Air Engine."* By Mr. W. W. Poingdestre.

After entering briefly into the theoretical considerations of the expansion of heated aëriform bodies, and detailing the attempts made by Lieut. Ericcson, for employing hot air instead of steam, as a prime mover, the author proceeded to state, that in 1837, Sir George Cayley, Bart., applied the products of combustion from close furnaces, so that they should act at once upon a piston in a cylinder, similar in every respect to that of a single-acting steam-engine. The engine consisted of a generator of heat, a working cylinder, and an air pump or blower, the air pump being half the size of the cylinder, and blowing air into, and through, a fire perfectly inclosed within the generator; the doors of the furnace were made perfectly air-tight as soon as the fire was well got up, the first impulse being given to the engine, by thowing a few jets of water upon the fire, which caused the air-pump to work immediately, and continued so for hours; the fire being replenished by stopping off the blast from the furnace, and opening the upper bonnet. After the air had passed through the fire, the gaseous products of combustion, generally at a temperature of 600° Fahrenheit, passed laterally through a chamber, used for separating them from any ashes or cinders, into the working cylinder before alluded to.

The difficulties attending this description of engine, were the liability of the working parts to be deranged, by the great sensible heat destroying the valves, pistons, and cylinders, and carbonising the lubricating oil. It was stated, that Mr. A. Gordon had made a successful experiment on the application of the heated products of combustion for propelling a boat, without the intervention of any machinery between the furnace and the water to be acted upon.

Feb. 19.—*"Description of the Iron Roof over the Railway Station, Lime Street, Liverpool."* By Mr. Richard Turner.

The area covered was described as being 374 feet in length, and 153 ft. 6 in. in breadth, which was roofed over in one span. The roof consisted of a series of segmental girders or principals, fixed at intervals of 21 ft. 6 in. from centre to centre; these were supported, on one side, upon the walls of the offices, as far as they extended, and on the other upon cast-iron columns. From the end of the offices to the Viaduct over Hotham-street, a distance of 60 ft. 4 in., the principals were carried upon "box-beam" of wrought-iron. The principals were trussed vertically, by a series of radiating struts, which were made to act upon them, by straining the tie-rods and diagonal braces they were trussed laterally by purlins and by diagonal bracing, extending from the bottom of the radiating struts to the top of the corresponding strut in the adjoining girder; these braces were connected with linking-plates by a bar of the same scantling, and also with the purlins already referred to. The girders were thus firmly knitted together, and a rigid framework formed, upon which the covering of galvanised corrugated iron and glass was laid.

The whole construction was minutely described, and the appendix contained an account of the experiments for testing the strength of the principals. These were made at the works of Messrs. Turner and Son, Dublin, under the direction of Mr. Locke, the engineer of the railway, when some great improvements in the construction were introduced at his suggestion.

SOCIETY OF ARTS, LONDON.

Jan. 16.—William Tooke, Esq., F.R.S. V.P., in the Chair.

Mr. Walls read a paper *"On California, its History, Products, Climate, and Prospects; being the result of a recent visit to that place, by* Alexander Cross, Esq."

On the table were placed a few specimens of Californian gold. one of which was a large lump, weighing almost seven pounds, being the largest ever imported into England in a pure native state, and the property of Mr. Cross. A few specimens were also exhibited by Professor Tennant. Mr. Walls commenced by stating the extent of the country and its population, which, including the recent accessions, amounted at the present time to 90,000 people.

The country along the sea-coast is healthy; but fever is occasionally prevalent in the interior. After describing the situation of some of the principal stations, he proceeded to describe the valley of San Joachim, its extent and boundaries, every spot in which is stated to have produced gold of twenty carats fine. Several extracts from various sources were briefly alluded to in the paper; and from these the following matters were collected. Two young men had discovered gold in a place 500 miles north of San Joachim, and described their operations as having been attended with considerable success, having made in their best day 400 dollars, in their worst 150 dollars. As to the moral condition of the people, many of them became rich very quickly; but some expended their gains in profligacy and dissipation, so that the poorer class was fast increasing. The annual exports of gold from this country, according to Mr. Bryant's work on California, amounted to between 100 and 200,000,000 dollars. In many places linen washing was so expensive, that it was considered more economical to throw away old linen, and buy new. Emigrants, as they arrived, passed beyond into the country, and were doing well. The general health of the community was excellent. The disparity of the produce of labour in various parts sometimes occasioned considerable confusion. A new settler in about three weeks would succeed, by washing, to obtain an ounce of gold a-day; but the moment that he hears that at a distant place others were washing three, he immediately packs up his things, goes away, and is generally disappointed.

Mr. **Tennant** stated the specimen of gold exhibited by Mr. Walls was evidently a water-worn fragment. The gold is usually found in small grains, which are obtained by washing the alluvial soil. He also exhibited a specimen of gold which at the time he had purchased it (about two months before) was the finest specimen of pure native gold he had seen; it contained ninety-two per cent. of pure metal. A reason he had for purchasing the specimen was, because it had some of the alluvial soil attached to it; and in that soil he imagined that one or two small diamonds might be detected, and was most anxious to ascertain that fact, as he had stated to the Society last session, in a paper, that diamonds, and other precious stones, might be found in the gold districts of California; and that such gems are being thrown aside, although the refuse diamonds sold to the lapidary to be broken up are worth 50*l.* per ounce, while gold is not worth more than 3*l.* 15*s.* He had not, however, been able to discover any diamond; but, on examining the soil with the microscope, he had detected some small crystals of garnet, two grains of platinum, and several of quartz, &c. In looking over a quantity of other gold specimens, he had found quartz in great abundance, and it had evidently formed the original matrix of the gold. He next called attention to the fact, that gold is not generally found in the position in which it was originally deposited. Mr. Tennant urged on the attention of persons about to visit the gold districts the necessity of making themselves acquainted with the few simple rules which should guide them in their search for gold, and other minerals, and which were published in the Society's *Circular* last session.

Mr. **Hopkins** stated that there was nothing unusual in the gold deposits of California. The gold was found precisely under similar circumstances at the deposits of the Ural in Russia, and some other places. When the west tributaries of the Sacramento and the San Joachim have been washed, California will doubtless be brought to the ordinary level of large gold-producing countries. He was of opinion that metals were formed in the crystalline rocks in flakes, masses, crystals, arborescent, &c., according to the degree of the electro-chemical action, and that this action in the moist crystalline rocks *in situ* was as constant as the growth of vegetation. The surface products and the veins, he said, were formed on the same principle. He perfectly agreed with the remarks that were made, that those called geologists and others, who have been led to suppose that such products were the result of volcanic action, were totally wrong. In fact, true practical and useful geology was known only to a few persons who have studied amongst the great works of nature. Mr. Hopkins concluded by stating that gold is generally found in the debris of feruginous granites and porphyries, and that the quantity of gold to be obtained depends on the elementary composition of the granitic rocks, the complete saturation to induce chemical action, so as to cause a kind of efflorescence of the metals into all joints, vacuities, &c., and the oxidation and disintegration of the superficies. In fact, he said that the superficial decomposition of the moist and friable auriferous rocks were more or less constant, the degree of action and the accumulations at the foot of the mountains being dependent solely on mineral and physical conditions confined to no age of rocks nor to any particular zone; and that this electro-chemical agent was constantly providing inexhaustible stores of mineral wealth for successive generations. When the decomposed and friable surface is washed down to the ravines and plains, he said, the gold and other heavy ingredients, especially the black titaniferous iron (the usual companion of the precious metal), were deposited in pools and other places, presenting obstacles to their descent, and consequently those places have become enriched by concentration, the lighter particles being constantly washed away; and that this was the origin of the riches of the tributaries of the Sacramento.

ROYAL SCOTTISH SOCIETY OF ARTS.

Jan. 14.—Thomas Grainger, Esq., President, in the Chair.

The following communications were made:—

"*Verbal Statement on the relative value of Chlorine, Nitric Acid, Sulphurous Acid, and Ozone, as disinfectants; and on the best method of applying them to destruction of Contagious Matters.*" By George Wilson, M.D.

The author dwelt at length upon the relative value and best mode of applying, as disinfectants, the different substances mentioned in the title of his paper. A chief object of the communication was to draw attention to the alleged virtues of ozone as a purifier of the atmosphere, and to notice that, in defect of any other disinfectant, ozone might be generated in apartments, the air of which was vitiated by animal exhalations. The simplest process for this purpose would be the exposure of moist phosphorus to air; but an electrical machine or voltaic battery might also be used. The other point at which the author aimed was to show the unwise neglect of the sulphurous acid as a disinfectant, or rather antiseptic, which had been practised. It appears, according to Dr. Wilson, that in the wine countries this gas is employed to arrest the acidification of the weaker wines; that in the Manchester Dye Works it is found more efficacious than chlorine in destroying the offensive odour which attends the employment of cochineal; and that at paper mills it is employed with great success to prevent the putrefaction of the *scrolls* or clippings of the skin used in the manufacture of the paper size. The author accordingly strongly recommended sulphurous acid as a cheap and powerful deodoriser and disinfectant.

"*Remarks on the Philosophy of the Beautiful; and an Analysis of the principle of Proportion, as applicable to Architecture.*" (Part I.) By David Cousin, Esq., Architect.

The author combated the definition of the beautiful, as laid down by the late Mr. Alison and Lord Jeffrey, and held that beauty was recognised by the mind in particular *forms*, independently of any association connected with the object which it admires. This first part of the communication was entirely metaphysical, and cannot well be given in abstract. The author will read at next meeting, the second or practical part of his paper, showing how Mr. Hay's principles of proportion, determined by angles bearing harmonic ratios to each other, can be applied to architecture.

Jan. 29.—A paper was read by Mr. Meik, C.E., of Sunderland, upon "*A New Self Registering Tide Gauge, lately erected and now in operation at Sunderland Harbour,*" which was followed by a paper read by Mr. Henry Watson, of Newcastle, describing "*The Application of Prepared Gauze, by which means the Gauge is observable by Night as well as Day,*" a very important desideratum.

The merits of Mr. Meik's paper consisted in directing particular attention to the necessity of all ports and docks having conspicuous gauges for the guidance of vessels inward or outward bound, and of those gauges being of the most simple and intelligible description. Mr. Meik had prepared, and showed in juxta position, the present signals used at Leith, and those brought forward by him. For the information of our readers we may mention, that the signals used at Leith consist of a series of balls and flags which have to indicate to seamen the depth of water. The new gauge, at a single glance, shows the height of the tide in feet by a number in figures corresponding to the depth of water on the bar of a harbour or entrance to a dock. The little attention we often find paid by seamen to the preservation of their own lives, shows the great advantage of having figures that can be at once easily understood, without consulting books, and thereby incurring a loss of time, which in many cases results in the loss of valuable life and property. Mr. Meik proceeded to show that a gauge having the property of being easily understood by all as "soon as seen," had been erected by himself, in conjunction with Mr. Watson, for the Commissioners of the River Wear at Sunderland Harbour. He then read the following description, which was illustrated by drawings:—

A well, carefully boxed in, and of exactly similar depth to the water on the bar, is made below the building which contains the apparatus. Within this well, in an interior pipe or trunk, and rising and falling with the tide, works a float suspended by a copper wire cord, which is carried over a spiral cone fixed in an upper story of the building. By the simple arrangement of a wheel and pinion at the opposite end of the axle to which the cone is fixed, a web of wire gauze works on two rollers fixed at the upper and lower ends of the web. The lower roller is regulated by the movement of this wheel and pinion, the upper one by a balance weight attached to a copper wire cord, which also passes over another spiral cone, having at the extremity of its axle a second wheel and pinion similar to the first. As the float rises and falls with the tide, the wheels and pinions connected with the cones, over which the cords of the float and balance weight respectively pass, move the rollers on which the gauze web travels. On this web are painted in large figures the various depths from high to low water; and as the web works, two points upon it indicate the number of feet and half-feet on the bar at any hour of the tide.

The web and the figures on it can be made of any size, and to travel 4, 6, 8, 10, or any other proportion, to 1 of the float, by regulating the size of the wheels and pinions. By day the figures on the web are shown white on a black ground; by night they are brilliantly lighted up, the ground still remaining dark. A white transparent varnish is used for the figures, and an opaque black for the ground. The illumination by night is so steady and powerful, that the figures, if made large enough, and the apparatus fixed at a sufficient elevation, will be visible at a considerable distance at sea, and thus afford vessels the means of knowing the exact depth of water, at the mouth of any harbour, before entering it. This simple piece of mechanism is applicable to all places where the want of a correct and conspicuous gauge has been felt, not only in harbours and docks, but at *railway stations for signals*, and such like purposes. The apparatus used occupies so little space, that it can all be contained and worked in a column or pillar without any other building.

Mr. Watson read a paper describing more particularly the preparation o the wire gauze, and exhibited a neat specimen, which, although small, fully and clearly illustrated the novelty and utility of the application.

INSTITUTION OF CIVIL ENGINEERS OF IRELAND.

Feb. 8—Lieut.-Col. Harry D. Jones, R.E., President, in the Chair.

The following papers were read:—

"*A Description of the Viaduct, near Quaker's Yard, Taff Vale Railway, South Wales,*" By Mr. S. Downing, Assistant Professor of Civil Engineering in Trinity College.

This viaduct was designed by Mr. Brunel, to carry the main line of the railway over the river Taff, at a point where, from the nature of the locality, such crossing was unavoidable. The total length of the viaduct was 470 feet, and the greatest height 105 feet, consisting of six semicircular arches, each 50 feet in span, resting on pillars, whose horizontal section was a regular octagon, 5 ft. 9½ in. in the side, giving 14 feet as their diameter. The whole structure was upon a curve of 1,320 feet radius, and at the point where it was determined to build, the axis of the river made an angle of 45° with the direction of the tangent to the curve. One of the chief merits of the design was the avoidance of the difficulties and expense of an oblique bridge with spiral courses in addition to those of curving; this was effected by the adoption of that form of pier above-mentioned. These pillars were surmounted by a capital of seven feet in height, the base of which, resting on the pier, was, of course, identical in plan with it; but in this height of seven feet was corbelled out on four of its faces to the extent of 1 ft. 3 in., changing the regular octagon into another, whose sides were 9 feet, and 3 ft. 7½ in. alternately. Two of the 9 feet sides were paralleled to the direction of the line of rails, and the other two formed the impost or springing of the arch. The easiest way to have an idea of the form of the soffit of the arches, is by conceiving an ordinary semicircular arch of 50 ft. span and 14 ft. length, to have the arch quoins bevelled off to an extent of 2 ft. 6 in.; and to turn this arch a corresponding centre had to be made. being the ordinary laggings for the cylindrical part, and what were called by the workmen saddles for the conical faces. It will be evident to the practical engineer, that the proper bonding of all this work, and especially the arches, must be a matter of great care. A model, cut out of Caen stone, showing four courses of the arch, was produced, which clearly showed the alternate arrangement of the course. The arches being turned, and the spandrils filled up, there was a clear width of 14 feet from outside to outside of the up-stream and down-stream faces of the bridge, giving ultimately 11 ft. 6 in. in the clear between the parapet walls for carrying a single line of rails over; nor, indeed, does it seem possible with any advantage to extend the design so as to carry a double way, for thus the pier would be necessarily extended in diameter, or otherwise the chamfering of the soffit increased—both inadmissible, one from interfering with the water-way, and the other from the practical difficulty of bonding the work.

The quarries from whence the stone was obtained were in the immediate vicinity of the works. It was of the blue Pennant grit, called by Sir H. De la Beche, in the Government Geological Survey of this district, "The equivalent of the Pennant grit of the British coal measures;" and very truly characterised by him as being admirably adapted for engineering purposes. Its colour closely resembles that of the common building limestone of this neighbourhood. The lime used was the celebrated Aberthan hydraulic limestone, not only in the foundations, but in all parts of the structure. The foundations on the north side, including one of the river piers, were on rock or indurated gravel; but on the south side the abutment, one land and one river pier, had to be sunk to a far greater depth than originally designed.

From the loftiness and peculiar design of this bridge, it was, during its construction, an object of great interest; and most persons who visited it expressed strong opinions unfavourable to its ultimate stability, most of which objections were very futile. The real difficulty in the construction was found to be the management of the spandril walls on the concave side, so as to gain the true uniform curvature at the stringcourse under the parapets, as on the concave side we had to gather out the courses of the spandrils about four inches, which, from the excellent quality of the stone, we were enabled to do.

It would seem necessary also to explain the reason for crossing the valley, and crossing it at such a height. Such structures seem rather to constitute the difficulty and expense of obtaining good gradients on cross-country lines, which necessarily intersect the rivers at elevations more or less considerable than that of a valley line, which, following the leading of one single stream, ought not, unless for cogent reasons, cross it at all. The consideration of the section of the river made it clear that no other alternative remained but this lofty and curved viaduct, intersecting the stream at the angle of 45°.

The paper was accompanied by a model of the river piers and cutwaters, with the centering and its supports, at a scale of one twenty-fourth, constructed under the author's direction by Mr. Keenan, and also by a diagram map, at two inches to the mile, showing the general features of the valley of the Taff—and another map, at six chains to the inch, showing the immediate locality of the viaduct, and the natural difficulties of the ground, with the added difficulty of carrying a line of rails through that district, from the great pre-occupation of the surface by the canal and its feeders, and the mineral tram-roads—and also a diagram section of the gradients of the line of railway, with a large isometrical drawing of two of the arches, showing by part section the arrangement of the spandril walls, the mode of closing them over as designed, and as carried out in the construction, with the form of the soffit, the capital, and pillar.

"*An Account of the Construction of the Midland Great-Western Railway of Ireland, over a Tract of Bogs, in the Counties of Meath and Westmeath.* By George W. Hemans, Engineer-in-Chief.

The railway from Dublin to Mullingar was projected, from motives of interest and policy, to follow the line, and occupy the banks, of the Royal Canal. The canal banks afforded some facilities for the construction of a railway, but it soon became evident that there were also disadvantages in following them too closely. The earthworks in constructing the canal, had been very heavy in character, with some of the deep cuttings through rock; and to relieve them as much as possible, the canal had been laid out to follow every sinuosity of the ground which offered a favourable level. The railway, as far as Mullingar, was also laid out along nearly the whole of these sinuosities; and there being great anxiety to open at least a portion of it at the earliest period, it was at once, on the passing of the bill, put into a contractor's hands for one-half the distance (as far as Enfield), and rapidly constructed on the canal banks. During the progress of these works, it was found to be desirable to avoid constructing the remainder of the line on a continued system of curves, which, although no longer, by well-informed engineers, considered a source of danger, are decidedly objectionable, as offering a resistance to the trains, causing greater friction, wear and tear, consumption of fuel, and loss of time besides lengthening the distance. In considering the plans for the second division of the line, between Enfield and Mullingar, the canal bank, which is a continued series of curves, was clearly to be avoided; but another difficulty presented itself on the straight line—the chord to these curves—it would have to traverse a long line of bogs, which, on careful examination with the boring-rod, proved to be from twenty-five to as much as seventy feet deep. Some of them were swell bogs of the softest pulpy nature, having gradually risen to a higher level than the surrounding country, and holding much water in suspension. After an extended examination of the subject, particularly in reference to drainage, it was at length apparent that one of the causes of the excess of water, and consequent want of solidity in these bogs, was the position of the canal embankment, traversing the edges of them for a great distance, and completely intercepting all drainage from them along the general fall of the country towards the river Deal. The following general plan was then at once resolved upon:—First, immediately to open full and sufficient new outlets for the escape of suspended water from the whole area; next, to form a system of drains all along and across the intended line; and finally, as a fixed principle, not to attempt either to excavate or embank the line, but to lay the rails on the natural level of the high bogs, trusting to drainage only to reduce the parts that were too high. With tolerable confidence in this plan, a Deviation Bill was passed through Parliament, and the straight line, traversing about eight miles of deep bog, was immediately commenced. An old wooden shoot, nine inches square, which was the sole outlet for the drainage of a district of about 1,500 square acres of wet bog, was the most ineffective point of the existing drainage, and was, therefore, the first to demand improvement. The banks and bottom of the canal at the place consist of clay artificially superposed on the cut away bog, lying on fine gravel of a very loose, treacherous description, being of a mixed sandy and marly nature. Having resolved on introducing a tunnel culvert, three feet diameter, under the canal at this spot, and that its invert should be six feet lower than the existing shoot, it became a matter of anxious consideration how to do this, in such bad ground, without interfering with the navigation of the canal, or running the risk of bursting a leak in the bottom. The canal level at this stage is twenty miles long, without a lock, and a breach would have been a serious affair.

Mr. Hemans here described very minutely the details of the execution of this very difficult work, which was altogether very successful, which secured the command for drainage of nearly four miles of the line of railway. The description of this important operation was further illustrated by reference to several drawings prepared for the purpose.

While the foregoing work was in progress, a sum of about 1,000*l.* was being expended in the sinking a length of some miles of a river, and underpinning a culvert, ten feet wide, leading out of the next district of bogs.

This underpinning and building a new invert, at a level four feet below the old one, was also a work requiring great caution. The weight of the embankment and the canal overhead was very great; and here also a breach would have caused extensive damages. As soon as these outlets were ready, the drains in the bog were opened.

Mr. Hemans next proceeded to enter into a very clear explanation of the plan of operation pursued in the drainage of the surface of the bogs destined to receive the upper works of the railroad. He then described the nature of the soling finally decided upon and adopted, having given an account of the results of experiments on the several descriptions of soling which had been tested,

The construction of the upper works of the railroad were minutely detailed, and explanatory drawings were exhibited.

The mode of operation adopted in conveying this line of railway over the bogs of most unpromising aspect was eminently successful; and as the details of the works were so very different from the very expensive process generally adopted, and sometimes with but little success, the account was particularly interesting to the engineering world.

Mr. Hemans having made some observations on the cost of maintaining railways constructed through bogs, and also on a paper of great interest by the Messrs. Mullens, published in the second volume of the Transactions of the Institute of Civil Engineers of Ireland, concluded by reading a detailed estimate of the cost of these works, which clearly showed the possibility of constructing a double line of railway over deep bogs, when treated as described by him, at a cost not exceeding 6,000*l.* per mile, including all expenses.

NOTES OF THE MONTH.

On the Basement Bed of the London Clay.—At the Geological Society, on the 23d January, a paper was read on this subject by J. Prestwich, jun., Esq. The position of the plastic clay formation, above the chalk and below the London clay, has been long well established. It has, however, been recently held doubtful how far the distinction between the London and plastic clay series can be maintained,—and some even regard the latter as merely subordinate beds of the former. The object of the paper is to show, that the lower English tertiaries form several distinct subdivisions, each marked by different conditions,—indicating ancient hydrographical and palæontological changes of importance. For this purpose very numerous sections were described,—exhibiting the position and character of the lower part of the London clay. This deposit is a nearly homogenous mass, several hundred feet thick, of tough clay, of a predominating brown colour. At its outcrop it inevitably rests on a conglomerate bed of round flint pebbles, mixed with yellow, green, or ferruginous sands in variable proportions,—which the author names the basement bed of the London clay. Except where denuded on the chalk downs, this bed extends uninterruptedly from the Isle of Wight to Woodbridge in Suffolk. The materials composing it seem to have been derived by denudation from the inferior tertiary strata. This bed contains 30 known and 8 or 10 still undescribed species of testacea. In the western part of the London district, the beds on which it rests contain no fossils; but at Woolwich, where it reposes on the fluviatile beds, six species of the estuary shells, found in the latter, also occur in the basement bed above, and four of them likewise in the freshwater series in the Isle of Wight. In the eastern district a few marine species are also introduced from the inferior tertiary beds. After deducting these, there remain 20 known species not found in the lower deposits, and constituting a distinct and well-marked group. Some of the species are very numerous and persistent through the whole range of the bed, but others die outwards towards the east; whence the author infers that the sea became shallower in that direction. In Essex and Suffolk, also, fossils are almost entirely wanting. From a table of the fossils it appeared, that the species were chiefly those of the London clay. It was, therefore, concluded that this bed forms a well-marked geological horizon, dividing this formation from the older eocene deposits.

The Screw Propeller.—On Monday, 11th February last, a question of considerable interest, in respect to steam navigation, was argued before the judicial committee, at the Privy Council Office, Whitehall, Lords Brougham, Campbell, and Langdale, Dr. Lushington, and Mr. Pemberton Leigh, being present. An application was made by Sir Frederick Thesiger, on behalf of the patentees of the screw propeller, for an extension of their patent, which expires in May next. The evidence went to prove, that no less than 30,000*l.* had been expended in building the Archimedes, and in defraying other weighty charges, to establish the screw-propulsion principle; and it further appeared, that although no less than 32 ships-of-war, and 100 mercantile steam-vessels had been constructed already upon this system, not more than two or three had paid for the patent license. These evasions had been occasioned by the conflicting claims of five different patentees; but, as these have now united in one association, it is expected that all who have adopted the use of the screw propeller will have to pay for their licenses. As the Admiralty are interested, either directly or collaterally, in this question, to the amount of about 25,000*l.*, Sir John Jervis, the Attorney-General, assisted by Mr. Crowder, Q.C., opposed the application for an extension of Mr. Frank Petit Smith's patent; but, after examining Capts. Chappell and Crispin, R.N., and Messrs. Brunel and Galloway, engineers, their lordships decided on granting an extension of five years to Mr. Smith's patent upon certain conditions; and there is now, therefore, a fair prospect of that gentleman and his supporters recovering a portion, if not the whole, of the licensing moneys to which they are unquestionably entitled.

Brass Rudder.—A Philadelphia paper describes a large brass rudder, just completed in that city for the steam-ship Columbia, of New York, 16 feet long, 3 feet 3 inches wide in the blade, and weighing nearly 3000 lb.

Bishop's Rock Lighthouse.—We are sorry to have an unfavourable account of Mr. Walker's new lighthouse, described in Mr. Cubitt's address (see "Journal," p. 42), as being built on the Bishop's Rock, near the Scilly Islands, with six hollow cast-iron columns. The "West Briton" of February 15th says, "The massive pillars and apparatus erected during the last three summers at a vast expense, were entirely washed away on Tuesday night (the 8th). A St. Agnes pilot-cutter had since been out to the rock, and the pilots are of opinion, the rock is quite safe and sound. The pillars are broken off, some at the base, others at two, three, four, and five feet from the foundation, evidently proving that the pillars were not sufficiently strong; the sea was breaking over the rock at the time the pilot-cutter passed. It was consequently impossible to land."

Great Railroad Rope.—A rope for the Columbia Railroad, west of the Schuylkill river, Pa, has been manufactured for the inclined plane, by Messrs. J. Whetham and Son, Philadelphia. It required 14 tons of hemp for its construction, and it was 6000 feet long, 9 inches round, and weighed when completed, 25,000 lbs. This rope was made in less than 10 days, and the manufacturers have given a guarantee that the rope should transport 80,000 cars over the plane, which, we understand, is about the average service performed by two previous ropes furnished by their manufactory.

Brett's Electric Telegraph.—The concession signed by Louis Napoleon and the Minister of the Interior, M. Dufaure, granting to Messrs. J. Brett, Toche, and Co., the right to establish an electric telegraph line between France and England, by a submarine communication across the Channel, has been authorised. The Company propose to establish, by means of the electric telegraph, an instant communication between the two countries. The patentee guarantees that this telegraph shall, by the aid of a single wire and of two persons only (the one stationed in France and the other in England), be capable of printing in clear Roman type (on paper), 100 messages of 15 words each, including addresses and signatures, all ready for delivery in one hundred consecutive minutes.

Manufacture of Ice.—Sir J. F. W. Herschell, in reference to the system of making ice by the expansion of highly compressed air (previously reduced to the ordinary temperature), in a letter to the 'Athenæum', says:—An old steam-boiler buried some 20 or 30 feet underground in well rammed earth, and furnished with a condensing pump (worked aboveground), and one eduction pipe opening by a stop cock through a rose into water, would in all probability supply ice, 'ad libitum', for the use of a family in the country—the condensation being performed over night.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM JANUARY 24, TO FEBRUARY 23, 1850.

Six Months allowed for Enrolment, unless otherwise expressed.

John Dalton, of Hollingworth, Chester, calico-printer, for certain improvements in and applicable to, machinery or apparatus for bleaching, dyeing, printing, and finishing textile and other fabrics; and in the engraving of copper rollers, and other metallic bodies.—January 26.

Edwin Heycock, of Leeds, York, merchant, for certain improvements in the finishing and dressing of woollen cloths.—January 26.

Thomas Richardson, of Newcastle-upon-Tyne, chemist, for improvements in the manufacture of Epsom and other magnesian salts; also alum, and sulphate of ammonia.—January 26.

Wincelas le Baron de Traux de Wardin, of Liege, Belgium, for certain improvements in looms for weaving linen, woollen, and cotton cloths; and in machines for preparing the yarns for such cloths, before entering the loom; and in a machine for finishing grey and bleached linen cloths.—January 26.

Thomas Schofield, of Combrook, Hulme, near Manchester, fustian dyer and finisher, and Henry Horabin, of Royton, near Oldham, fustian cutter, for improvements in machinery for cutting fustians and certain other fabrics, to produce a piled surface.—January 26.

Thomas Berger, of Hackney, gentleman, for improvements in the manufacture of starch.—January 26.

Richard Roberts, of Manchester, engineer, for improvements in the manufacture of certain textile fabrics, in machinery for weaving plain, figured, and terry or looped fabrics, and in machinery or apparatus for cutting velvets and other fabrics.—January 29.

Donald Beatson, of Green-street, Stepney, Middlesex, mariner, for certain improvements in instruments for taking, measuring, and computing angles.—January 29.

Ewald Riepe, of Finsbury-square, Middlesex, merchant, for improvements in the manufacture of steel,—January 29.

Joel Spiller, of Battersea, Surrey, engineer, for improvements in cleaning and grinding wheat.—January 29.

John Mason, of Rochdale, and Mark Smith, of Heywood, Lancaster, machine makers, for certain improvements in machinery or apparatus for preparing, spinning, and weaving cotton, and other textile materials; and also improvements in the method of preparing yarns or threads, and in the machinery or apparatus employed for such purposes.—January 29.

Francis Edward Colegrave, of Brighton, gentleman, for improvements in saddles; parts of which improvements are also applicable to the standing rigging and other furniture of ships or vessels, and to the connecting links or chains of railway carriages, and other purposes, where tension combined with a certain degree of elasticity are required.—January 29.

James Templeton of Glasgow, manufacturer, for certain improvements in manufacturing figured fabrics, principally designed for the production of carpeting.—January 29.

William Edward Newton, of Chancery-lane, civil-engineer, for improvements in machinery or apparatus for making hat bodies, and other similar articles. (A communication.)—January 29.

Thomas Berry, of Salford, Lancaster, silk, worsted, and piece dyer and finisher, and Nathan Ramsden, of Salford, in the said county, calendarman and finisher, for certain improvements in the construction of machines for glazing, embossing, and finishing woven fabrics and paper.—January 31.

Albert Dummler, of Mark-lane, London, for improvements in obtaining fibres from textile plants.—January 31.

Etienne Joseph Hanon Valck, Belgium, miller, for improvements in grinding.—January 31.

Edward Highton, of Clarence-villa, Regent's-park, Middlesex, engineer, for improvements in electric telegraphs, and in making telegraphic communications.—February 7.

Charles Atherton, member of the Institution of Civil Engineers of London, for an improved apparatus or machinery for regulating the admission of steam to the cylinders of steam-engines.—February 7.

Thomas Auchterlonie, of Glasgow, North Britain, manufacturer and calico printer, for improvements in the production of ornamental fabrics.—February 7.

Edward Ormerod, of Manchester, mechanical engineer, and Joseph Shepherd, of Charlton-upon-Medlock, in the same county, mechanical engineer, for improvements in, or applicable to, apparatus for changing the position of carriages on railways.—February 7.

Louis Jean Jacques, Viscount de Serionne, of Paris, gentleman, for certain improvements in the manufacture of buttons, and in the apparatus and machinery used therein.—February 9.

Bryan Donkin, the younger, of Bermondsey, Surrey, civil engineer, and Barnard William Farey, of Old Kent-road, Surrey, civil engineer, for improvements in steam-engines; and an improved fluid meter.—February 9.

Read Holliday, of Huddersfield, for improvements in lamps.—Feb. 11.

William Blinkhorn, of Sutton, Lancaster, glass manufacturer, for certain improvements in machinery, to be used in the manufacture of glass.—February 11.

James Webster, of Leicester, engineer, for improvements in the production of gas for the purposes of light.—February 12.

John Mackintosh, of Berners-street, Oxford-street, civil engineer, for improvements in obtaining power in the floating of bodies; and in conveying fluids.—Feb. 12.

Thomas Whiffen, of Pig's-quay, Bridewell Precinct, accountant, for improvements in machinery for registering the delivery of goods.—February 21.

John Steven Woolrich, of Wednesbury, Stafford, chemist, John James Russell, of Handsworth, in the same county, and Thomas Henry Russell, of Wednesbury aforesaid, patent tube manufacturers, for improvements in obtaining cadmium and other metals and products from ores or matters containing them.—February 21.

Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for improvements in separating and assorting solid materials or substances of different specific gravities. (A communication.)—February 21.

John Slack, of Manchester, Lancaster, manager, for certain improvements in the manufacture of textile goods or fabrics, and in certain machinery or apparatus connected therewith.—February 21.

Alexander Hediard, of Paris, France, gentleman, for certain improvements in propelling.—February 21.

George Holworthy Palmer, of Westbourne-villas, Harrow-road, Middlesex, civil engineer, and Joshua Horton, of the Ætna steam-engine boiler and gasometer manufactory, Smethwick, near Birmingham, Stafford, for improvements in the arrangement and construction of gas-holders.—February 21.

William Cormack, of King street, Dunstan-road, Haggerston, Middlesex, chemist, for improvements in purifying gas; also applicable in obtaining or separating certain products or materials from gas-water, and other similar fluids.—February 21.

William Mayo, of the firm of Mayo and Warmington, Silver-street, Wood-street, Cheapside, manufacturers of mineral aerated waters, for improvements in connecting tubes and pipes, and other surfaces of glass and earthenware.—February 21.

John Scoffern, of Essex-street, Middlesex, M.B., for improvements in the manufacture and refining of sugar, and in the treatment and use of matters obtained in such manufacture, and in the construction of valves used in such and other manufactures.—February 21.

LECTURES ON ARCHITECTURE,

By Samuel Clegg, Jun., Esq.;

Delivered at the College for General Practical Science, Putney, Surrey.

(PRESIDENT, HIS GRACE THE DUKE OF BUCCLEUGH, K.G.)

Lecture IV.—Pelasgic remains in Greece, Italy, Asia Minor. Architecture of the Jews.

It is singular, that in those countries where Art advanced the most rapidly towards perfection, we should be able to ascertain the least respecting its origin and progress. The history of the earliest races inhabiting these favoured regions is so enveloped in myth and mystery, that even the fact of their having really existed might be doubted, did not so many giant ruins remain to attest the work of their hands. These remains, whether found in Asia Minor, Greece, or Italy, are generally known by the name of "Cyclopean" or "Pelasgic." It is not necessary to our purpose, to enter upon the complicated question as to the what, or whence, of these great builders of the olden time. This is not the place to determine whether the Cyclopes (believed to be one-eyed, from the circumstance of their wearing helmets with one aperture) were a tribe of Celtæ from Asia, or from Sicily, or whether their name was applied indiscriminately to any unknown race of great strength. It is enough to know, that among the ancients the name "Cyclopean" was given to any work requiring more than ordinary power. As for the Pelasgians, the learned Niebuhr declares their very name cannot be pronounced by the historian, without a feeling of distrust, on account of the want of evidence as to their origin and the derivation of their name, and the many conflicting opinions concerning them. Wherever their native country may have been, they certainly soon spread themselves over a wide extent of territory; for we find these mysterious wanderers preceding the Hellenists in the Peloponnesus, and, together with the Etruscans, Umbrians, and Ænotrians, sharing the Tyrrhenian name in Italy.

For the sake of classification, it is convenient to call the walls formed by rough blocks of unhewn stone, piled rather than fitted on to each other, by the name of "Cyclopean;" while the walls constructed with accurately-fitted, uncemented polygonal or quadrangular blocks may be distinguished as "Pelasgian." The first kind, or Cyclopean masonry, which may have been adopted by any race of builders in a rude age, was composed of blocks of great size, irregularly shaped, and rough as they were taken from the quarry, the interstices being filled-in with small stones. The second kind, or Pelasgian, belongs to a more advanced state of society. The use of polygonal blocks, no doubt, originated in the natural cleavage of the stone. The blocks were carefully dressed, and frequently even polished, to insure their being accurately fitted. Quadrangular stones were, of course, substituted when the cleavage assumed that form; but they were not hewn to a size, nor laid in regular courses—a style of masonry belonging to a still more civilised age, and no doubt originating with a brick-making people. Remains of polygonal masonry, of beautiful workmanship, are to be found at Pterium or Tavium, in Asia Minor, at Cosa in Italy, and in various other places in both countries. Mr. Dennis speaks of the polygonal blocks forming the walls of Cosa as being so exquisitely fitted, "that the joints are mere lines," and says that not even "a penknife" could be inserted between them, the outside surface being as smooth as a "billiard-table."

According to Strabo, the position of cities may be cited as an accurate test of civilisation and social security: judging by this rule, the Pelasgians must have been a wild race, for they chose the steep rocks rising abruptly from the plain, on which to found their eyrie; and here they built those huge walls,

> "Piled by the hands of giants,
> For god-like kings of old,"

—walls which have defied the power of time, as once they defied human adversaries.

In most of these ancient fortifications, the walls were guarded by square towers at intervals, where sentinels were posted to give notice of impending danger. Alarm was given by means of fire; hence they were called torch or beacon towers. The gates were in all cases defended by towers, even where the walls were plain. Gates seem to have been considered as necessary evils, or were as few in number as possible; many of these old cities only possessing two. The multiplication of gateways was considered as the greatest proof of the strength and valour of the community; and thus cities were celebrated by the number of their gates, like Thebes. The gates were small in size, and were at first made of wood, and secured by wooden bars; as the arts progressed, the wooden doors were strengthened by plates of brass or iron, and had bars of metal. No city, defended by these Pelasgian fortifications, could be overcome by the engines then in use, and were never taken except by stratagem or treachery: thus Troy owed its fall to the wooden horse, and the Bœotian Thebes was voluntarily abandoned by its citizens, under a warning from the gods.

It is well for human progress that the first settlers *had* rendered their rocky fortresses thus impregnable, that those who had begun to acquire the arts of civilised life should be able to protect their strongholds against the ruder and poorer; and should retain their position until political organisation and discipline was sufficiently matured in rival states to allow them, in their turn, to achieve and maintain the superiority. In course of time, as the population became too dense to occupy the summit of the hill, they spread themselves over the plain below; the original city was then distinguished by the name of "Acropolis," or upper town, and not only formed the citadel, but was considered as consecrated ground—where the shrine of the tutelary deity was erected, and the treasures and archives deposited. At first, probably, the lower town consisted only of wooden huts, which are supposed to have furnished the model for future erections in stone; such huts as form the dwellings of the peasantry of Asia Minor at the present day.

The Homeric poems present us with a picture of some degree of civilisation, as having existed in Greece at that early time—walled towns, fixed abodes, individual and hereditary landed property, carefully-cultivated vineyards, altars to the gods, and palaces for the chiefs. In the earliest ages we have no mention of temples, or statues of the divinities; but the sacrifices appear to have been offered on an altar in the court of the palace, where the king or chief officiated. In the time of Homer, the shrine at Delphi was merely a small wooden structure, covered in with laurel branches. The little we know of the palaces of the ancient Greek kings is derived from the pages of Homer. The following description of the house of Alcinoüs gives an idea of splendour and luxury, though displayed in somewhat barbaric taste.

> "The walls were massy brass: the cornice high
> Blue metals crowned, in colour of the sky;
> Rich plates of gold, the folding doors incase;
> The pillars silver, on a brazen base;
> Silver the lintels deep projecting o'er,
> And gold, the ringlets that surround the door.
> Two rows of stately dogs, on either hand,
> In sculptured gold, and labour'd silver stand.
> These Vulcan formed with art divine, to wait
> Immortal guardians at Alcinoüs' gate.
>
> * * * * * *
>
> Fair thrones within from space to space were rais'd,
> Where various carpets with embroidery blazed,
> The work of matrons."
>
> ——Od: Pope's Homer.

We are reminded by the rows of guardian dogs, at the door of the house of Alcinoüs, of the dromos of sphinxes leading to the palace of the Egyptian kings. From the Homeric poems we may also obtain a glimpse of the interior arrangement of these ancient dwellings, as the bard no doubt described the palace of Ulysses after the general plan of houses of that age. They appear to have been built in three divisions: first, the aula, or open court, surrounded by apartments. This court had a peristyle, or colonnade, round it, covered with a pent, or roof; beneath this was spread the couches for the men. Telemachus and Pisistratus are described as sleeping beneath this colonnade, in the palace of Nestor. In the centre of the aula, stood the altar: in the palace of Ulysses it was dedicated to Jupiter.

> ———————"With timorous awe,
> From the dire scene th' exempted two withdraw;
> Scarce sure of life, look round, and trembling move
> To the bright altar of protecting Jove."
>
> ——Odyssey.

The aula was entered by gates from the street; and opposite the entrance was a portico or vestibule, leading to the second division, which included the great banqueting-hall; this appears to have been a splendid and spacious apartment, the roof supported by columns, and the walls hung with tapestry. When Minerva visits Telemachus, the suitors are sitting on hides or skins, in the vestibule, feasting and playing at chess. Telemachus leads Minerva into the great hall, and receiving the spear from her hand, places it against a column. We are not acquainted with the third division, the gynæceum, or women's apartments; it is evident that they inhabited an upper story, for the females are invariably described as descending when they make their appearance in the other part of the house. The gynæceum seems to have communicated with the banqueting-hall by folding doors: thus, speaking of Penelope—

> "Touch'd at the dreadful story, she descends;
> Her hasty steps a damsel train attends.
> Full where the dome its shining valves expands,
> Sudden before the rival powers she stands."
> ——Odyssey.

The aula was paved with marble; but the floors of the inner apartments were of polished wood, as were also the imposts of the gateway. The chamber where the treasures were kept is described as having a floor of polished oak, and the roof supported by columns, from one of which Penelope took down the bow of Ulysses. Attached to the house was a base court, which contained the stables, granaries, and other farm buildings; in this court was a circular structure, with a conical dome, called a tholus; it had a wooden pillar in the centre, but for what use this building was designed is uncertain—it may have been a store-room, or perhaps a threshing-floor.

Egyptian influence has been suggested by the tapering form of the doors and windows in Greek architecture; but it must be remembered, that while the exterior wall of Egyptian buildings assumed a pyramidal form, the apertures were always vertical; in the Greek, on the contrary, the doors and windows only sloped inwards, the exterior wall being invariably vertical.

According to Pausanias, Lycosura in Arcadia was the most ancient city in Greece; a few Cyclopean walls only remain.—Tiryns in Argos follows next in date, and is said to have been founded 1710 B.C., upwards of 900 years before the first recorded Olympiad. Both Homer and Hesiod mention the well-built walls of Tiryns: those of the Acropolis are formed of enormous blocks of unhewn stones; the external wall varies in thickness from 19 ft. 9 in. to 25 ft. 3 in.; many of the blocks of which it is constructed are 10 feet in length, and some as much as 13 feet in length by 4 ft. 4 in. in thickness; their breadth is from 3 feet to 7 ft. 6 in. The gallery of Tiryns is the most ancient vault in Greece; the doorways are formed by stones placed obliquely, and meeting at the summit, thus forming a kind of pointed arch: this form is met with wherever Cyclopean remains exist.

We know nothing of the inhabitants of this city, except from an anecdote Athenæus has left us. It seems they were a wonderfully frivolous and light-headed people, making a jest of the most serious matters, and always ready for a laugh; at last this propensity became beyond a joke, and they applied to the oracle at Delphi for some means by which to get quit of their superabundant hilarity. The answer vouchsafed was, that they were gravely to sacrifice a bull to the god Poseidon, and with equal gravity to cast it into the sea. On an appointed day, the inhabitants of Tiryns assembled to witness the much to be desired consummation, and behaved with becoming decorum; till an unlucky youth, repelled in his endeavour to force his way through the crowd, exclaimed, "What! are you afraid I should swallow your bull?" This idea so tickled the fancy of the giddy-pated multitude, that they burst into a loud laugh, the sacrifice was interrupted, and they thenceforward resigned themselves to an inevitable destiny.

The most perfect and interesting Pelasgic ruin in Greece is the ancient Mycenæ, in Argolis, the capital city of the unfortunate race of Atreus. Its early kings were so wealthy, as to gain for it the title of the "Golden Mycenæ." The citadel is an oblong, nearly 1000 feet in length, and is entered by two gates, on opposite sides. There were towers on each side the gates, but none round the walls. The custom of consecrating gates, by placing over or upon them sacred images, has existed in every period of history: the Gate of the Lions (so called), at Mycenæ, is an example of this time-honoured usage. As the citadel was consecrated ground, the principal entrance-gate was likewise holy; the image placed above was the symbol of the tutelary deity, the hieron before which the people worshipped: as in Ezekiel xlvi. 3., "Likewise the people of the land shall worship at the door of this gate, before the Lord, in the Sabbaths and in the new moons;" and again, in Psalms, lxxxvii. 2, "The Lord loveth the gates of Zion more than all the dwellings of Jacob." The people of Mycenæ and Argos were worshippers of Apollo, as the Sun-god, the same divinity as the Indian Bacchus.* The animals sculptured above the gateway are evidently intended for panthers, not lions: the panther was consecrated to the Indian Bacchus; the orb and pillar, placed between the panthers, were also dedicated to Apollo, or sun worship.

Not only were religious ceremonies performed, but markets, and courts of judicature, were held before the holy gate; for this purpose, a paved court or open space was necessary, where the kings or judges could hold their sittings on solemn occasions. This custom is alluded to in many passages of holy writ, as in Deuteronomy xvi. 28: "Judges and officers shalt thou make thee in all thy gates, which the Lord thy God giveth thee, throughout thy tribes; and they shall judge the people with just judgment." In 1st Kings, xxii. 10: "And the king of Israel, and Jehoshaphat the king of Judah, sat each on his throne, having put on their robes, in a void place in the entrance of the gate of Samaria, and all the prophets prophesied before them." In the Book of Proverbs, i. 21: "She crieth in the chief place of concourse, in the openings of the gates;" and in Prov. xxxi. 23: "Her husband is known in the gates, when he sitteth among the elders of the land." At Mycenæ, the walls of the citadel project in parallel lines, so as to form an area, or oblong court, before the gateway. The Lions' Gate is now nearly filled up with earth and rubbish, so that its height cannot be ascertained; it is 9½ feet in breadth; the stone forming the lintel is 15 feet in length, 6 ft. 8 in. in breadth, and 4 feet in height. The panthers, with the orb and pillar, are sculptured on a piece of green basalt, of triangular form, which is let in above the lintel: the opposite gateway is constructed in a similar manner, but the triangular stone above the lintel is plain, not sculptured. In some instances there would seem to have been an outer gate, as David is described as sitting *between* the gates, waiting to hear the result of the battle between Joab and Absalom.

Ancient Gateway, Asia Minor.

There is a very curious gateway in Asia Minor, near the Turkish village of Euyuk, equally illustrative of the custom to which I have just alluded. The imposts are nearly 12 feet in height: on the outside of each is sculptured a sphinx-like figure in high relief—monstrous creatures, with human heads, birds' bodies, and lion's claws; these were, no doubt, the sacred hiera, perhaps symbolical of regal government. The walls, which are Cyclopean, here advance about 14 feet on each side the gateway; the stones forming the lower course round the court are squared, and rudely sculptured with figures in low relief. Within the gateway there is an avenue of large stones, which must have led into the city. This ruin is perhaps one of the most curious relics of the heroic age now in existence.

These gateways with upright imposts and a flat lintel across, may be called Cyclopean, as they are always found in connection with rude unhewn masonry; when the span was too great for a block of stone, a wooden beam was placed across as a lintel.—Pelasgic gateways are generally rude arches, formed by the courses of stones projecting one over another, capped by a flat stone at the summit: the accompanying drawing is an illustration of this style of construction—the Gateway of Ancient Ephesus, which, it will be observed, approaches very closely to the perfect arch in outline.

Immediately without the walls of Mycenæ, rises a mound or tumulus, and within this is the tholus or vaulted chamber, sometimes called the Treasury of Atreus, but now generally known as the Tomb of Agamemnon. The treasury of Atreus is mentioned as a brazen chamber; but this vault could scarcely have been so described, even if the walls had been lined with metal plates, as has been conjectured from the nails in the wall. Nor is it probable that a treasury, containing the wealth of the state, would be situated without the walls of the citadel; besides, the very form of the tumulus seems to announce a sepulchre; and the comparison

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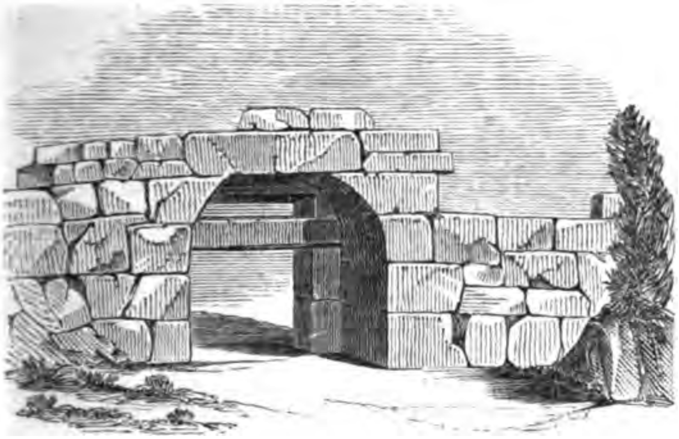
* Here again we meet with a remnant of the old Mithratic worship.



Gateway of Ancient Ephesus.

of the situation with the allusions to the tomb of Agamemnon, in the Electra of Sophocles, leaves little doubt of its identity. The entrance to the vault is a doorway of elaborate design, sculptured in green basalt; a restoration from the fragments remaining is published in the supplementary volume of Stuart and Revett's 'Antiquities of Athens.' The doorway was originally approached by steps, but the earth has now accumulated above the threshold. It differs widely in design and detail from the Greek of after ages: the door or gate was brazen; the columns are decidedly Asiatic in character; the capitals closely resemble the Egyptian, though the bases approach the Greek in graceful outline; the peculiar scroll forming the principal decoration is quite distinct from the Greek meander, but is met with in some of the Egyptian tombs; the vandyke may have been suggested by a section of the palm. On the triangular tablet the panthers with the orb and pillar are carved in relief. The vaulted chamber is circular, 48 feet in diameter; the present height is 49 feet, but it must originally have been much higher, as the ground has been raised by the earth and stones falling in. This vault is formed in the usual Pelasgic manner, by the projecting courses of stones, afterwards hollowed out, and indicates no knowledge of the principle of the arch. The stone used is the hard breccia, found upon the spot: 36 regular courses are exposed to view; they are uncemented, but united with the greatest precision. The wall of the building is 18 feet in thickness; consequently, there is a passage 18 feet in length between the outer and inner door. The stones forming the roof of this passage are of enormous size: the lintel of the inner doorway is composed of two blocks, the largest 27 feet in length, 17 in breadth, and 3 ft. 9 in. in thickness, the weight being about 133 tons—a block only inferior in size to those of Karnac and Baalbec. A small square chamber opens from the larger apartment.

A sepulchre of somewhat similar construction has been discovered on the site of the ancient Cære, formerly the still more ancient Agylla, one of the earliest Pelasgic settlements in Italy. This tomb (known by the name of its two discoverers, Regulini-Galassi) is entered by a Pelasgic archway: the chambers are oblong, instead of circular, but vaulted in the manner already described. This sepulchre was opened for the first time only a few years ago: the funeral beds stood in their original places, with the armour and jewels upon them, though their occupants had long crumbled into dust; shields, spears, and other weapons, as well as vases and pateræ of various forms, were suspended from the walls by nails. As we know that the traditional rites of burial were religiously observed by the early races, we may conclude that the nails in the wall of Agamemnon's tomb were for the purpose of attaching sepulchral furniture, rather than brazen plates.—Mycenæ was destroyed by the Argives, 500 B.C.

At Orchomenes, in Bœotia, are other interesting Pelasgic remains; amongst which may be mentioned the Treasury of Minyas, a vaulted chamber of still larger proportions than the Tomb of Agamemnon. It was once covered by a dome, but the upper part has now fallen in. This building was considered by the ancients as one of the wonders of the world, equally with the pyramids of Egypt and the walls of Tiryns, and is said to have been the work of the celebrated Agamedes and Trophonius.

In Bœotia are the remains of the greatest, as well as the most ancient engineering work achieved by the Greeks. Between the Kopaic lake and the sea, is a mountain of calcareous limestone, called Mount Ptoôn: the river Kesephus is formed by the overflowing waters of the lake finding or forcing their way through the fissures of the mountain. These did not, however, afford a sufficient channel, and frequent inundations were the consequence. To remedy this evil, artificial tunnels were cut through the whole breadth of Mount Ptoôn. The north-eastern tunnel is rather more than 3½ miles in length, with about twenty vertical shafts let down into it along the whole distance. The shafts are now choked up, but the apertures are yet visible, and are about 4 feet square; the deepest is supposed by Forchhammer to be about 150 feet. These shafts are thought to have been for the purpose of allowing a greater number of workmen to be employed at the same time, so as to carry on the work more quickly—just for the same reason that we sink shafts at present. It is said that these tunnels were cleared out and repaired by Crates of Chalcis, who, according to Strabo, presented a report to his employer, Alexander the Great, stating that the remains of several ancient cities had been brought to light, formerly submerged by the overflowing of the Kopaic lake.

There are many more Cyclopean and Pelasgic remains in Greece and the neighbouring islands, but they merely consist of huge walls, with here and there a gateway more or less perfect.

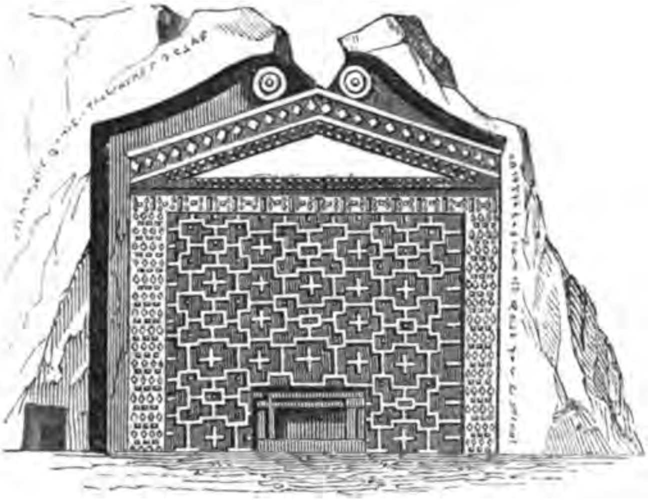
Asia Minor, that beautiful peninsula thrown (as Laborde observes) like a bridge between Asia and Europe, notwithstanding the genius of its people, never formed a great kingdom: its destiny was to become a battle-field, where a succession of heroes struggled for the dominion of the world. The names of Crœsus, Cyrus, Xerxes, Xenophon, Alexander the Great, Mithradates, hallow every spot of ground with a thousand historical associations, even before the foundation of the Christian churches gave a still more vivid interest to the land. It was anciently divided into several small kingdoms, that sometimes successfully struggled against, and sometimes succumbed, before the power of Persia. After the check given to the Persian dominion by the defeat of Xerxes, the numerous cities on the coast of Ionia, Ætolia, and Caria, founded by emigrants or exiles from Greece, increased in power and importance, and rivalled the mother country in art, in science, and in literature. After the battles of the Granicus and Issus, won by the great Alexander, Asia Minor was united to the Macedonian kingdom, but again dissevered at his death, when his successors, Antigonus, Eumenes, and Lysimachus, obtained possession of different provinces. In the year 133 B.C., Attalus Philopater, king of Pergamus, bequeathed his kingdom to Rome; but the peninsula was not completely subjected to this mighty empire till after the defeat of Mithradates, the great king of Pontus (65 B.C.)

In each of the small kingdoms of Asia Minor, a distinct style of architecture seems to have prevailed; though of this variety, the tombs alone remain to bear witness. Truly, as Shelley says,

> ———————— "Dead men
> Hang their mute thoughts on the mute walls around:"

and the abodes of the dead frequently bear record of a race whos living habitations have long disappeared. In each little kingdom, the ancient mode of sepulture seems to have been religiously adhered to, whether under Greeks or Romans, to as late a date as the Christian era. From the innumerable excavations in the rocky districts of Asia Minor, it has been supposed that they were not only used for sepulchral purposes, but had in still more ancient times been the retreat of some Troglodytic or cave-dwelling tribe, like the ancient Edom. It is possible that the rocks may originally have afforded shelter to such a race, and their caves have been converted into sepulchres by subsequent inhabitants: but this is all conjecture. In Cappadocia, Phrygia, and other provinces, many chains of rocks are completely honeycombed with excavations—perforated with thousands of chambers, niches, and passages.

Phrygia, being an inland kingdom, was further removed from the influence of the Greek colonies, and approaches more nearly to the Persian in architectural style. The characteristic of Phrygian tombs is the sculptured façade chiselled on the surface of the rock; some are rude and simple, others elaborately decorated. The Tomb of Midas is one of the most richly ornamented. This sepulchre takes us back to the fabulous ages: we at once remember Midas, king of Phrygia, son of Gorgias, that miser of the olden time, who prayed that whatever he touched might be turned into gold; and when his prayer was granted, would have starved to death in the midst of his riches (every morsel being transmuted as it touched his hungry lips), had it not been for the tender mercy of Bacchus, who ordered him to bathe in the river Pactolus, when its sands were changed into gold, and Midas was relieved from his fatal gift. Thus cleansed and purified from his golden fever, he might have been a happy man, had he not committed the folly of taking the weaker side against the stronger, in a contest between Apollo and Pan, when he was punished with a pair of asses' ears by the angry Sun-god; he was likewise tormented by evil dreams, in attempting to relieve himself from which, he died, and it is to be hoped slept well at last in his gorgeous tomb. The tomb at any rate is real, and remains to this day. The rock upon which it is carved is of volcanic tufa, isolated, and presenting a surface of about 1316 square feet. The sculptured surface, exclusive of the margin and pediment, is about 41 feet by 37 feet. The outside measurement of the niche is about 17 feet wide and 3½ feet deep; but the interior is not above 6½ feet in width, and so shallow, that it is difficult to conceive how a human corpse could have been deposited there. The niche must formerly have been closed by a slab of stone, upon which the ornamental pattern was continued. Over the pediment are two circular forms, meant to represent either shields or volutes; and there are other richly-sculptured façades in the neighbourhood, wiih similar ornaments.



Tomb of Midas, King of Phrygia

The custom of suspending shields, not only over sepulchres, but on the city walls and on the temples, was so ancient and universal, that there is every reason to believe such to have been the origin and intention of these ornaments, even when they take a more volute-like form. Ezekiel alludes to this usage in chap. xxvii., v. 11: "They hanged their shields upon thy walls round about; they have made thy beauty perfect;" and we know that the ancient Greeks frequently presented shields as votive offerings, when they were suspended on the walls of the temple.

Many Phrygian tombs are sculptured in the form of a richly-ornamented and panelled doorway; but the door is fictitious, the opening to the tomb being above. These tombs are entered by shafts pierced in the rock, with niches in the sides, at intervals, to facilitate the descent. In some instances, the excavated rock-chambers communicate by means of these chimney-like shafts; so that tier after tier, and chamber after chamber, may be traversed, like a vast mine in the heart of the mountain. In some caves, sarcophagi are found; in others, funeral beds; and, in many, no traces of their having been occupied, either by dead or living.

In Lycia and Xanthus, the tombs differ widely from those of Phrygia; many of the excavated chambers have apertures singularly resembling the heavy mullioned windows of the middle ages; these are generally finished with denticulated ornaments and pediments. In Xanthus, sepulchres are found in the form of towers, something resembling in form high pedestals: perhaps they may formerly have supported sphinxes, or statues. The tower or pillar is a very ancient form of monument, immediately succeeding the stone of memorial; there are two of great antiquity in the north of Syria, between Tripolis and Tartous. The pedestal of the first is about 6 feet in height; on this there are said to have been four sphinxes, but they are now too much mutilated to be recognisable. On the pedestal stands a circular column, about 20 feet in height, divided into two parts, by a denticulated ornament, and surmounted by a small pyramid. The other pillar or tower stands at a distance of about 30 feet from the first, and is of similar form, except that the summit is dome-shaped, instead of pyramidal.

The most remarkable tombs in Xanthus and Lycia are those in the form of sarcophagi, raised upon a pedestal; they are evidently hewn after the model of constructions in wood, and differ from those of any other region hitherto explored. I use the word *Sarcophagus* instead of the correct Greek term *Soros*, as being more familiar. According to Pliny, a peculiar stone, found in the neighbourhood of Assos, in Asia Minor, had the property of consuming the bodies inclosed within it, whence it was called by the Romans *sarco-phagus*, or flesh-eating.

Ancient Towers north of Syria.

The Lycian and Xanthian sepulchres display a mixture of Greek and Persian, or perhaps Assyrian taste; many of them are richly decorated with bas-reliefs, as may be seen by referring to the Xanthian marbles in the British Museum. One great peculiarity of these tombs is the high-pitched roof, though such must have been familiar to Homer, for in a passage in the Iliad, he compares Ajax and Ulysses grasping each other in wrestling to the pointed roof:—

> "Close locked above, their heads and arms are mix'd,
> Below their planted feet at distance fix'd;
> Like two strong rafters which the builder forms,
> Proof to the wintry wind and howling storms;
> Their tops connected, but at wider space,
> Fix'd on the centre stands their solid base."
>
> ——Iliad.

In Caria, also, the sepulchres are elaborate and beautiful. According to Mr. Hamilton, they form three sides of a square, the fourth being against the side of a hill, and must have the appearance of porticoes leading to temples within the rock. At Halicarnassus, in this kingdom, was the celebrated tomb of Mausoleus, king of Caria, erected to his memory by his widow, Artemisia, who is said to have drank up her husband's ashes, in despair, at his death. Unlike many inconsolable widows, she never married again, but died broken-hearted in less than two years, after having superintended the erection of this splendid monument, intended to perpetuate her love and grief. This tomb stood upon a platform 411 feet in circumference; four architects were employed in its construction; and as it was built at the time of Greek pre-eminence (about 353 B.C.), was doubtless in the Greek style. It was called the *Mausoleum*, and was so renowned for its beauty, that it has given a name to all magnificent places of sepulture of subsequent erection.

In the Troad, and in Lydia, it was the custom to construct a tumulus over the grave. Mr. Hamilton says, that in one plain in Lydia, there are upwards of sixty tumuli, called by the Turks Ben Tepéh (the thousand hills.) The largest one, known as the Tomb of Halyattes, is nearly half-a-mile in circumference. I have mentioned the antiquity of the custom of burying under a tumulus in a former lecture. Homer refers to it in the following passage:—

> "Now all the sons of warlike Greece surround
> Thy destined tomb, and cast a mighty mound;
> High on the shore the growing hill we raise,
> That wide the extended Hellespont surveys;
> Where all from age to age, who pass the coast,
> May point Achilles' tomb, and hail the mighty Ghost."
>
> ——Odyssey.

It would be neither interesting nor instructive, to enter further into the antiquities of Asia Minor, rich as it is in remains of the rarest architectural works. The beautiful ruins of Ionia, Ætolia, &c., will be included in the history of Greek architecture; and any further notice of those existing previous to the rise of the Hellenic colonies, would but be a tedious list of Cyclopean and

Pelasgic walls and gateways, in no essential point differing from those already described.

Deeply interesting as is the history of the Jews in other respects, as far as regards architecture it is almost a blank. The Jews, having been a pastoral people, never became great builders, and acquired no style of their own. Though Jerusalem is a city of great antiquity, having been founded (according to Manetho) by the Hycsos after their expulsion from Egypt, we have no description of any of its buildings previous to the erection of Solomon's Temple. The first Jewish structure on record is the Tabernacle, which Josephus describes as "a moveable and ambulatory temple." It was 52 feet in length by 21 feet in breadth and height, and had twenty quadrangular pillars on each side, and six at the end or posticus. The front was placed so as to have an eastern aspect, that it might catch the first rays of the sun. The pillars were of wood, covered with thin plates of gold; and as the structure was to be moveable, the pillars were fitted into their bases, and the gold or gilt bars forming the architrave into each other, by a tenon and mortice, so that they could easily be taken down, and set up in a new place. The interior of the Tabernacle was divided into three parts, as it might be the vestibule, pronaos, and adytum; the latter being the most holy place, where the ark was deposited. The Tabernacle was placed in the midst of a court, or sacred inclosure, formed by slender brazen pillars or staves, with cords from one to another, on which curtains were hung; these staves terminated in a sharp end, like a spear-head, which was stuck firmly in the ground. Within the court was the brazen laver or vessel for purification.

We learn from the sacred writings, that when David built his house, he sent for an architect from Phœnicia; and king Solomon followed the example of his father, when preparing to build his temple and palace at Jerusalem. Hiram, king of Tyre, not only sent an architect, but also provided other workmen, and much of the necessary materials. It is very difficult to obtain any clear conception of the Temple of Solomon; the description in the 1st Kings, and 2nd Chronicles, dazzling the imagination with a vague idea of gorgeousness, but not giving sufficient data for an accurate plan. Many different opinions prevail on the subject: Mr. Bardwell, says, "the temple of Solomon had not in its proportions and details any thing in common with the temples of Greece;" and presumes it to have been altogether copied from those of Egypt; while Mr. Wilkins, in his valuable work on Magna Græcia, supposes the Temple of Solomon to have been the model after which the Greek temples were constructed. Objections may be made to both these opinions. The Temple, which was to be a stationary Tabernacle, closely resembled it in proportion and distribution of parts; and so far, the first idea of the building may have been borrowed from what they had seen in Egypt; but it is scarcely likely that the Hebrews would have been desirous of building a temple to the Most High, constructed exactly after the model of the idolatrous temples of the abhorred land of Egypt, every recollection of which was so associated with slavery and degradation, that even brick-making became as great an abomination in their sight, as the Shepherd life was to the Egyptians. On the other hand, it is unlikely that the Greeks should have copied from Solomon's Temple; they had no religious motive for so doing, and had but little intercourse with Judea. Josephus, in his letter against Apion, says, "there was no occasion offered us in ancient ages for intermixing among the Greeks;" and afterwards observed, that being an inland people, the Hebrews were comparatively unknown to them. The most probable conclusion is, that as a Phœnician architect was employed, he would construct the Temple of Solomon as nearly as possible after the plan of those of his own country; and as there is little doubt that Greek architecture also originated in Phœnicia, there would naturally be a great similarity between the Jewish and Greek temples, though the plan would be adapted to the requirements of the people, and their peculiar mode of worship.

Three years were occupied in preparing materials and hewing stones for the temple of Jerusalem, and seven years more in its erection; the walls were constructed of stone covered with cedar, and the roof entirely of cedar wood. Josephus says, speaking of the skill displayed in the masonry, that the polished stones were "laid together so very harmoniously and smoothly, that there appeared to the spectators no sign of any hammer or other instrument of architecture; but as if, without any use of them, the entire materials had naturally united themselves together, that the agreement of one part with another seemed rather to have been natural than to have arisen from the force of tools upon them." The interior of the temple was divided into two parts, the oracle and the sanctuary; there was also a porch or vestibule before the front of the temple towards the east.

The proportions of the building (taking the cubit at 21 inches,) were, including the porch, 140 feet in length, by 35 feet in breadth; the oracle was a cube of 35 feet, the sanctuary 70 feet in length, the remainder being given to the porch. Instead of a peristyle, the Temple of Solomon was surrounded on three sides by a number of small cells or chambers three stories high, each chamber 8 ft. 9 in. square, thus giving a total width to the building of 43 ft. 9 in. This arrangement was not unique: there are the ruins of a temple in Lydia which has a set of small cells extending the whole length of the flank. Access was gained to the upper stories by a staircase in the thickness of the wall, and light admitted into the sanctuary by a row of narrow windows or loop-holes above the chambers. The whole of the interior of the temple, including floor and ceiling, was overlaid with gold. The oracle was divided from the sanctuary by a pair of folding doors of carved cedar wood richly gilt, and also by coloured and embroidered veils of fine linen: the sanctuary had similar doors leading to the porch. In the porch were the two great pillars, called Jachim and Boaz; these were massive brazen columns, with vase-shaped capitals, enriched with net-work and foliage. Round the temple were three courts, each one elevated a few feet above the next. The highest, nearest the temple, was called the Priest's court, because the priests only were permitted to enter; here stood the great brazen altar, and the molten sea, and other lavatories; this sacred inclosure was surrounded by a wall between 5 and 6 feet in height. The next, the court of Israel, was quadrangular, contained cloisters, and was entered by a great gate on each of the four sides; into this, says Josephus, "all the people entered that were distinguished from the rest by being pure and observant of the laws." The outer division was called the court of the Gentiles; this was surrounded by a double row of cloisters, supported by stone columns, and roofed over with polished cedar; here only the public were freely admitted.

This magnificent edifice was destroyed by Nebuchadnezzar, 586 B.C. The temple was rebuilt on the return of the Jews from captivity, but not in its original splendour, for we are told that when the festival of its completion was celebrated, the old men and priests, remembering the superiority of the original building, broke out into tears and lamentations, so that "their wailing overcame the sounds of the trumpets and the rejoicing of the people." This second temple, after sustaining various injuries, such as having been plundered by Antiochus Epiphanes, and desecrated by Pompey, was consumed by fire during the siege of Jerusalem by Titus, A.D. 70.

The Palace of Solomon was situated near the temple, and must have vied with it in splendour; it appears to have been arranged on a similar plan to the Eastern palaces of our own day, in large open courts, surrounded by different apartments. Solomon's palace consisted of three divisions, the centre one containing the great hall of judgment and other public offices; the rest of the building formed the residences of Solomon and his Egyptian queen. The principal apartments are described as having floors of cedar; the walls were inlaid part of their height with polished marble. Above this was a row of sculptured slabs representing foliage, and between these slabs and the ceiling the wall was plastered and richly painted; thus closely resembling the interior of the palaces of Nineveh. There were also cloisters for exercise, and, according to Josephus, "a most glorious dining-room." He continues: "Now it is very hard to reckon up the magnitude and the variety of the royal apartments; how many rooms there were of the largest sort, how many of a size inferior to those, and how many that were subterraneous and invisible, the curiosity of those that enjoyed the fresh air, and the groves for the most delightful prospect, for the avoiding the heat and covering of their bodies; and to say all in brief, Solomon made the whole building entirely of white stone and cedar wood, and gold and silver. He also adorned the roofs and walls with stones set in gold, and beautified them in the same manner as he had beautified the Temple of God with the like stones."

Of the private houses of the ancient Jews we know little, except that they were flat-roofed, and of two or more stories, as frequent mention is made of "the upper chamber." The flat roofs were used, as in the East at the present day, both for exercise and repose, and it was commanded by law that each house should have the roof protected by a parapet.

Most of the buildings now existing in Palestine are Saracenic; the most ancient do not date beyond the time of Herod, with the exception of the tombs of the Patriarchs. The celebrated Sepulchre of the Kings, near Jerusalem, is undoubtedly Roman in design; it is by some supposed to be the work of Herod, and by others to be the tomb of Helena, queen of Adiabené, who had become a convert to the Jewish faith: there are still the remains of a beautifully sculptured façade; a low doorway conducts into a large chamber, hewn out of the solid rock; from this branch off several small crypts, with ledges on which to deposit bodies or coffins; a flight of steps leads to a lower set of chambers, similar in form and arrangement to those above: here some beautiful white marble sarcophagi were found.

The Tombs of the Patriarchs are situated in the valley of Jehoshaphat, on the eastern side of the Brook Kedron; the names assigned to them are the Tombs of Jehoshaphat, James, Zachariah, and Absolom: the two latter are the most elaborate. M. de Chateaubriand speaks of these tombs as displaying a manifest alliance of the Egyptian and Grecian taste; "from this alliance," he says, "resulted a heterogeneous kind of monument, forming, as it were, the link between the pyramids and the Parthenon."

The Tomb of Zachariah is shown in the engraving; it is monolithic, and consists of a square, with four engaged Ionic columns and two pilasters on each side. The Ionic are of the rudest kind, and bear the stamp of great antiquity. The entablature is finished with the ancient head-and-cavetto moulding, and the whole surmounted by a pyramid.

Tomb of Zachariah.

The Tomb of Absalom consists of a mass of rock, 21 feet square, standing in a recess of the hill which surrounds it on three sides. It has two engaged Ionic columns and two pilasters on each side; the frieze is ornamented with triglyphs; on this square stands a dome, and above this again a spire, the summit of which expands like a bell-shaped flower. This is supposed to be the building referred to in 2 Samuel, xxviii. 18: "Now Absalom in his lifetime had taken and reared up for himself a pillar, which is in the King's Dale; for he said, I have no son to keep my name in remembrance, and he called the pillar after his own name; and it is called unto this day, Absalom's Place."—The tombs of Jehoshaphat and James are simple excavations.

The art of fortification was always encouraged by the Jewish kings. Jerusalem, and especially its citadel, Mount Zion, was well defended by strong walls and towers; these have now given place to more modern fortifications. Well may the Jews keep the Day of Desolation in gazing upon Jerusalem, when of all the magnificent and stately buildings that once adorned it, not a ruin remains: but, instead, Roman walls and Saracenic mosques, telling of a succession of conquerors. Palestine has still much to engage the attention of the antiquary, but little, as has been seen, to attract the architect in his inquiry into the architecture of the Jews.

In the next lecture I shall speak of Etruria, stone buildings after the wooden model, and the foundation of Rome.

LIST OF AUTHORITIES.

Ancient and Modern Architecture, Gailhabaud.—Travels in Greece, Dodwell.—Travels in Greece, Dr. Clarke.—Tour in Greece, Dr. Wordsworth.—Cyclopean and Pelasgic Remains, Dodwell.—Antiquities of Athens, Stuart and Revett.—Descrisione di Cere Antica, Canina.—Magna Græcia, Wilkins.—Notes on Vitruvius, Wilkins.—History of Greece, Grote.—Cities and Sepulchres of Etruria, G. Dennis.—l' Italia avanti il dominio dei Romani, Micali.—Asia Minor and Lycia, Sir C. Fellows.—Travels in Asia Minor, Hamilton—Voyages en l' Asie Mineure, Laborde.—Voyages en l' Asie Mineure, Texier.—Homer, Pope's translation.—Bible History of Palestine, Kitto.—History of the Jews, Josephus.

PRINCIPLES OF DESIGN.

Rudimentary Treatise on the Principles of Design in Architecture, as Deducible from Nature, and Exemplified in the Works of the Greek and Gothic Architects. By Edward Lacy Garbett, Architect. Parts I. and II. London: Weale, 1850.

We have a well-known line of Homer, that "life is a mingled skein of good and ill:" and this is what we must say of this book, to give anything like a knowledge of it. There is ill enough in it to condemn any book; and yet there is as much good as would make a book. If it were a work on strict science, the failings would be fatal; but as it is on a debateable and unwrought subject, perhaps we owe much to the writer for what is new, true, and good, instead of having any right to blame him for what is otherwise.

It was a token of health when the outcry began about the want of taste and originality in building—this set men thinking; but had this gone on, we should have been brought to a more sickly mood than we were before. It is easy to blame; any one can do that—it costs nothing; even the youthful critic is sharp enough in finding out a blot, a blunder, or a want: and the world, always ready enough at it, was set grumbling. Grumbling is good, if we have not too much of it; but we wanted something more—we wanted to know what was to be done, as well as what was not to be done. That is the step to which we have now come, and it is a further token of health.

So long as humdrum swayed, woe betide the unlucky wight who strove for anything new; the herd of dullness' sons soon brought him to the ground. The way, however, is now opened; men may think and do, if they know what to do; the chains of mock classicality are snapped asunder, and skill is free. Slowly has a school of criticism risen, such as we have never yet had: and if the laws of knowledge are not yet settled, if the whole field is not beaten, and every nook searched out, yet we have hope before us, which we have never had before. The works of Leeds, Pugin, Jopling, Alison, Whewell, Willis, Hay, Fergusson, Ruskin, and we shall have to say, of Mr. Garbett, have each laid open something new.

If, however, any one thinks all is now right, and watchfulness at an end, he will reckon without his host. The cant of classicism we have got rid of; but the cant of criticism threatens us. Quackery is not so soon laid; it is a ghost which takes many shapes—and when driven from one, grins at us in another. There is little need of warning as to the 'Seven Lamps' of Mr. Ruskin; quackery is written on the forehead—the mysticism of the Seven Lamps wears throughout: but there is likewise some of it elsewhere.

To review Mr. Garbett's book, we should need to write another at least as long, for at every leaf there is something to be said; but as we do not feel the call upon us to undertake such a task, we must lighten our work by again telling the reader, that it is a book from which he may learn a great deal, but must not believe everything that is set down for him. The end Mr. Garbett has in sight is, to lay down the laws of design as drawn from nature; and this is a great thing to be done. Why he has so often missed, and why so many others have missed, is from having gone about it in the wrong way.

The groundwork of all lawmaking is a thorough knowledge of things. We hardly need Bacon to teach us this; and yet all this is to be done for the work Mr. Alison and Mr. Garbett have undertaken. It was the want of this, which, under the Aristotelian school, brought every kind of knowledge so low; and in nothing perhaps was this so striking at the new birth of learning, than in the knowledge of beasts. Othello's gleanings of natural history, "of men whose heads beneath their shoulders grow," were got from the field of learning. The Hortus Sanitatis, or any other blackletter book of the kind, will show what were the laws of nature believed in in Shakspearian times: and so far as design goes, we are not much better off now, and on the very same ground, inasmuch as no one has undergone the toil of setting down every shape to be seen in nature, and drawing the laws from them. The laws have been drawn up first; such things as help them, brought forward; the things against them left out of sight, or twisted in some wrong way.

The want of a sound groundwork has made much of Mr. Garbett's building rotten; but we are bound to acknowledge that he has done the best he could. He has an earnestness in his work, an enlightened feeling, good knowledge of his business, and is thoroughly well read in the learning of art. He neither blindly follows any man, nor stubbornly sets himself against him; what he thinks right in any one, he takes with fair acknowledgment: and if he or any of the others had, indeed, settled the laws of nature or of design, his would be a good hand-book on the subject.

What Mr. Garbett has done, shows moreover what may be done; that art is not without laws, though we do not know them all. When the reader has gone through this book, he has still to read Fergusson and the others, to make up his mind what he will believe and follow out. Nevertheless, we may fairly say Mr. Garbett's book is a step forward.

Having shown what is the root of the evil, we shall not put the book away without a few words as to some of its teachings. Mr. Garbett lays it down, that no building has a right to be selfish; but he rides this hobby too far the wrong road, being afraid, as he says, of going on that to communism. This is some of the cant of the day; and is giving a worth to a name which does not belong to it. If a thing is right, we may stick to it without fear of its name; and we need not wander from the field of building, for a stalking horse on the field of politics. If man is not made to be selfish and live alone, then it is his bounden duty in a building, as in everything else, to show some feeling for his fellows. As he can have no right of himself, but only by the law of the land, to run up a building, so he can have no right to run up a building which is unsightly. The least he can do, if only as a reward for the leave given to him, is to build right.

We may say, by-the-bye, that Mr. Garbett gives his meaning to the word æsthetic—a word which is a stumbling-block laid in the way of art by our High Dutch neighbours; and which the sooner it is got rid of the better, for what it means no one knows. We are sent back to *aisthetikos*, and thence to *aisthanomai*; then we are brought forward from the Greek and Greek-English to Latin-English; and told that æsthetic means *sensuous*, or *relating to the senses*, which in English are the feelings. Esthetics seems to have been meant by the High Dutch for the knowledge of the laws by which beauty impresses the feelings; but esthetic may mean a number of things, as it is understood in its several Greek, Latin, English, or High Dutch relations.

REPORT OF THE COMMISSIONERS APPOINTED TO INQUIRE INTO THE APPLICATION OF IRON TO RAILWAY STRUCTURES.

The last notice of the Report of the "Iron Commission" referred to the manner in which empirical formulæ had been obtained for connecting the longitudinal compression and extension of cast-iron with the corresponding elastic forces. "The law of elasticity," it is said in Appendix A, "constitutes the very basis of all sound knowledge of the statical and dynamical properties of girders."

The "revision of that law" is undertaken as one of the subjects of this Appendix. The investigation was conducted by one member only of the Commission—Mr. Hodgkinson—whose experience and persevering research as an experimenter, render empirical deductions obtained by him worthy of the most careful consideration.

In the preceding number of this *Journal* (page 92), was given one of his tables for Extension of Cast-Iron, showing the relation between different suspended weights, and the extensions produced by them.

The results of computing the extensions from a certain empirical formula are also given, and the errors or deviations from the observed results. These errors, in five cases out of fifteen, deviate from the real result by about one-fiftieth part; the smallest of the remaining errors is the two-hundred-and-eighty-fourth part. Now, although these errors may seem small in themselves, they cease to appear so when it is reflected, 1st, that the empirical law assumes the character of "the very basis of all sound knowledge of the statical and dynamical properties of girders;" 2nd, that the formula is not deduced from abstract theory, but from the experiments themselves, and is in fact no more than a synopsis of their results.

Under the first head, we observe that any error in the empirical law becomes enormously multiplied when it is applied to the theory of girders. The result of integration and other analytical processes involved in that theory, is that the magnitude of the original error is not at all commensurate with the magnitude of those it induces. We are to remember that the old law of elasticity (that of direct proportion of the longitudinal forces to the extension or compression) led to the inference, that in a girder the central deflection and transverse pressure were in direct proportion also. This result, however, was not *quite* true. A *small* increase of deflection above that due to the proportional increase of pressure was observed; and the former increase was due to a *small* error in the assumed law of elasticity. It may easily be supposed that this "small increase" and "small error" (though small considered separately with reference to the results from which they were respectively derived) are not small with *respect to each other*. This is the best way in which we can put the argument, without aid of mathematical language: *that* would show that the "defect of elasticity" of the deflected girder is a quantity of the same order as the "defect of elasticity" of the longitudinally compressed or extended rod.

In the table above referred to, the "errors" or deviations of the formula from experiment, are given "in parts of the real weight" stretching the rod: but if the errors had been given in parts of the much smaller quantity—"the defect of elasticity"—they would have appeared much larger.

The second head of our remarks is this, that the formula is essentially empirical. It depends on no abstruse investigation; and all that is required is a method of representing observed results in the short-hand of mathematics. The way in which this has been done, appears unscientific in its principle as well as unsatisfactory in its results. Two empirical coefficients a and b were to be obtained in a formula

$$w = ae - be^2,$$

where w is the tensile force and e the extension.

If the formula were absolutely exact, and experiments could be made which were absolutely exact also, two experiments would suffice to determine a and b. But, because that accuracy is practically unattainable, it was of course the case that any pair of experiments would give values of a and b differing from those of another pair of experiments: we have a remarkable instance of this at page 58, where it is stated that by one pair of experiments, the value of b obtained was 177290·03, and by another pair, the value of b was 221163·17.

Now, in selecting the pairs of experiments for this computation, no sort of system or scientific method appears to have been adopted—the selection was made entirely at random. This process *might* have produced satisfactory results, but the chances were immeasurably against its success. At all events, the accuracy of the final formula so obtained could not but rest on a much lower kind of evidence than that in favour of a formula formed in accordance with the mathematical laws "in that case made and provided."

The mathematical laws of combination of observations are definite and exact. Practical astronomy is almost made up of such combinations, in which several results are to be represented by a formula which shall give the closest possible approximations. The importance of the subject in physical science long ago led mathematicians to perceive that they must combine their results by fixed principles, and not by taking averages indiscriminately. Gauss, the author of the *Theoria Combinationis Observationum*, proposed the celebrated rule of Least Squares, which has been independently discussed by Legendre, Laplace, Poisson, Ivory, and others.

To the kindness of Mr. Adams, Fellow of St. John's College, Cambridge, we have been privately indebted for copious examples of the application of the method to the case before us; he has also pointed out a very simple method of extending the formula, to include the *cube* of the extension. The agreement of the theoretical and computed results then becomes extremely close and accurate: when two terms only are taken by the method referred to, though the formula is considerably improved, it still falls short of the required degree of accuracy. This systematic method of computation has the advantages not only of superior accuracy but of superior facility—the labour which it involves is far less than that required by taking averages without regularity of order.

We may quote the same high authority for the opinion that the experiments on Compression, given in the Report, cannot be represented accurately by a formula involving even the third power, still less by one extended only to the second power. A very careful consideration has led us to the conviction that the irregularities arise *in the experiments themselves*, and that the errors of observation are probably much greater than in the experiments on *tension*.

The experiments on compression were made in this way:—a bar, 10 feet long by 1 inch square, was inclosed in a strong iron frame, open at both ends, to permit the free compression of the bar longitudinally, but to prevent, as far as possible, its lateral flexure.

The frame was made in two parallel pieces, which were screwed together, and thus adjusted, as nearly as possible, to the size of the bar; so that it "had thepower of being moved by the hand, but no power of deviation from the right line of its position." In other words, there was a good fit, but not a tight one.

Unfortunately, however, though the bars were intended to have no power of deviation from the right line, they assumed it for themselves. Whether that the frame was not screwed up sufficiently at first, or that it was not strong enough, or that the screws yielded, certain it is, that this bending of the bars, which it was all-important to avoid, actually took place. At page 64 we find the following:—

> "*Remark.*—The great difficulty of obtaining accurately the decrements and sets from the small weights in the commencement of the experiments, rendered those decrements and sets, particularly the latter, very anomalous; it was found, too, that some of the bars which had been strained by 16 or 18 tons had become very perceptibly undulated. It has not been thought prudent, therefore, to draw any conclusions from bars which have been loaded with more than 14 to 16 tons; and it may be mentioned that the results from 2 to 14 tons are those only which ought to be used in seeking for general conclusions."

Now, if the bar "*very perceptibly* undulated" in some cases, it is reasonable to suppose that it undulated in less degree in others. A flexure quite inappreciable by the naked eye would altogether vitiate any inferences from the experiments as to the law of elasticity. The contraction of the rod after it has been bent, is no longer measured solely by compression in the direction of its length, but partially by the diminution of the chords of certain curves—the curves of flexure. And it is to be remarked, that the diminution of these chords affects more especially those very terms in the formula which are principally sought for—the terms after the first, which express the defect of elasticity.

Moreover, leaving the geometrical consideration, in a mechanical point of view the case presents great difficulties. The external compressing force is no longer resisted by direct compression alone, but by compression and transverse pressure compounded. Again, if the bar closely fitted the interior of the frame originally, it must have bulged the sides of the frame when it got bent. Consequently, at those points where the bar most deviated from the right line, it must have pressed strongly against the frame.

Now, the effects of the pressure in question may be illustrated as follows:—Let a thin, flat rod of wood, whalebone, or steel, be placed on a table, and abut at its two ends against fixed points, so as to curve slightly upwards from the table. It will be seen that a very slight pressure on the summit of this curve will produce a very greatly multiplied pressure on the points of abutment; also the multiplication will be greater as the rod is less bent.

It is obvious from this, that the bent cast-iron rod, by pressing against the sides of the inclosing frame, must have derived great support to resist the external force to which the experimenter subjected them. Obviously, serious errors would arise from supposing the only external forces acting upon the bar to be those applied at its ends.

These considerations lead to the anticipation that the experiments would present anomalies: and this certainly appears to be the case. Without minute reference to the actual figures of the tables, the whole of the anomalies could not be specified: their general nature may, however, be briefly indicated.

1st. The ratio of the compressing weight to the compression ($\frac{w}{d}$ in the tables), instead of regularly decreasing in each set of experiments, alternately increases and decreases in an irregular manner. There are four kinds of iron—Low Moor, Blaenavon, Gartsherrie, and a mixture of Leeswood and Glengarnock—for which the ratio is given (pp. 65 and 66). The first three sets of experiments consist of thirteen results each, and the last set of twelve results. Let us suppose the results numbered in their numerical order, 1, 2, 3, &c., and let + or — indicate that the ratio for one result is greater or less, respectively, than that which follows it. Then, for the results on each iron, the fluctuation of the ratio will be expressed as follows:

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Low Moor	—	+	—	—	+	+	+	—	—	+	+	+
Blaenavon	+	—	+	+	—	+	+	+	+	—	+	+
Gartsherrie	+	+	—	+	+	+	+	+	—	+	+	+
Leeswood & Glengarnock.	+	+	—	+	—	—	+	+	+	+	+	

The plus sign occurs 34 times, and the minus sign 13 times, in the above synopsis; consequently, as the plus sign indicates a descending ratio, the number of ascending ratios is more than one-third the number of descending ratios. Now, in the formula of the Report, it is assumed that the ratio constantly descends; accordingly, the abnormal are more than one-third of the normal results. It may be shown, by simple analytical reasoning, that if the formula include only two terms, the ratio of the weight to the compression must be either always ascending or always descending; that if the formula extend to three terms, the ratio may be ascending to a certain point, and then descending, or conversely; and that if the ratio be ascending and descending several times alternately, there must be more terms in the formula.

2nd. The experiments for different sorts of cast-iron indicate widely-different physical properties in them. The ratio of the weight to the compression differs greatly for corresponding experiments in the four different sorts of iron: and not only is the ratio different absolutely, but its fluctuations are different also. This is shown in the foregoing synopsis, and a remarkable instance occurs in the tables on the two last kinds of iron, of which the first is represented as much less easily compressible than the latter at the beginning of the two sets of experiments, and more easily compressible at the end of those experiments. This may be possible, but it is not probable. At all events it renders invalid all general inferences taken from collecting (as at page 67) the means of the results for materials exhibiting such different properties; just for the reason that it would be improper to collect in one table the experiments on marble and ivory, and deduce a single formula for the elasticity of both. But this is precisely the way in which the formula for compression of cast-iron has been obtained.

It is to be observed, however, that in the table in which the mean results of compression of *all four* sorts of iron are given, the ratio of the weight to the compression is generally a descending one. This circumstance removes the impossibility of expressing the elasticity by a formula of two terms. It is barely possible also, that in thus collecting the means, the errors of the original experiments might destroy each other. But when the errors inseparable from the methods of those experiments, and the discrepancies among them, are considered, such a compensation appears extremely improbable.

The formula is obtained only from the mean results of all the irons—no formulæ are given for each iron separately. The foregoing considerations explain this circumstance. In the experiments of *tension*, however, where the results are much more trustworthy, and *the ratio is a descending one in every case with a single exception*—formulæ are given for each iron. The omission of formulæ for each iron compressed cannot, therefore, be considered accidental: if attempts to supply such formulæ have been made and omitted from the Report as unsuccessful, the failure must be attributed to the analytical principles which we have above enunciated.

Doubtless, experiments on compression of long bars present great difficulties; but we can conceive of no method of insuring their accuracy while the inclosing frame is retained. The fact of such a frame being required manifests that the experiments are not what they profess to be—experiments on direct compression—but experiments on compression and flexure combined.

If the subject be taken up anew, some means must be devised of compressing the bars without the chance of lateral support interfering with the accuracy of the results. But to compress the bars in this way, they must have such a section—the cruciform, for instance—as of itself has great power to resist flexure. If the compressing force be applied by a lever, the angle through which it moves in the course of the compression might be read off by the microscope. We offer these suggestions by no means confidently, but in the hope that they may stimulate endeavours to solve a most important practical problem.

In the case of tension, the experiments seem comparatively free from difficulty. It might perhaps have been worth while to have given a correction for the effect of the weight of the rods themselves, and the couplings, which were heavy masses of metal: and this correction might have been applied without much difficulty. In other respects, the results of experiments on tension appear exempt from general causes of error.

We have somewhat minutely examined the subject, because of its great practical importance, and because we have questioned the validity of the formulæ for compression and extension proposed as the basis of theory of girders. But as these formulæ are given on the authority of an able experimenter, who has the highest claims to respect, we shall be glad to find that the views here expressed have been reviewed, and if need be, revised, by investigators of high scientific repute.

RAILWAY CARRIAGE AND WAGON SPRINGS.

(*With Engravings, Plate* IV.)

On Railway Carriage and Wagon Springs. By Mr. J. W. Adams.—(Paper read at the Institution of Mechanical Engineers.)

The object of this paper is to discuss and analyse the various forms and descriptions of springs now in use in Railway Carriages and Wagons; pointing out, to the best of the writer's knowledge and experience, their advantages and defects, and suggesting such improvements in the details as will lead to better effect and economy in their use and manufacture.

Buffing and bearing springs are applied to carriages and wagons in order to absorb and neutralise as far as possible the force and momentum of the shocks to which the vehicles are exposed in their ordinary work. A perfect bearing or buffing spring would be that which would absorb the entire power and space of the blow without disturbing the inertia of the vehicle. This in practice is wholly impossible, from the varying loads on bearing springs and varying force on buffing springs. In bearing springs the nearest approach to perfection is in the modern first-class carriage, where the disproportion of total weight between loaded and unloaded is less than in any other vehicle.

At the present time, as far as the writer is aware, there is no rule or formula by which engineers or manufacturers can ascertain the true form, weight, or quality of material to be used for effectually springing a railway vehicle, and consequently the goods and mineral traffic of the country, averaging from 35 to 40 cwt. per spring, is now carried on springs which vary in weight from 35 to 110 lb. each.

The primary object being in all cases to discriminate between good and bad material, the writer has endeavoured to test the relative quality of spring steel converted from Swedish and from English iron. For this purpose bars of ordinary spring steel were procured from various makers, some being English and the others Swedish; the bars were all 3 inches wide and $\frac{5}{16}$-inch thick. These bars were cut to equal lengths, marked, and then made into springs and tempered in the ordinary manner; each of the springs consisting of a single plate turned over into an eye at each end, and 18 inches long between the centres of the eyes. These springs were then proved in the presence of Mr. W. P. Marshall, by means of pressure applied at the centre of each spring, the spring being supported by a pin passed through the eye at each end, which rested on rollers to allow the ends to be drawn together freely when the spring deflected. The results were as follows—

English.

No.	Weight.	Deflection.	Permanent Set.
1.	15 cwt.	1 inch	no set
	20 „		⅛ inch
	25 „	Broken	
2.	15 „	1⅜ inch	no set
	20 „	2¼ inch	1 inch
	25 „	Broken	
3.	15 „	1½ inch	⅛ inch
	20 „	3⅜ inch	2¼ inch
	25 „	much set	
4.	15 „	1⅝ inch	¼ inch
	20 „	2⅞ inch	1⅜ inch
	25 „	much set	

Swedish.

No.	Weight.	Deflection.	Permanent Set.
5.	15 cwt.	1⅝ inch	⅜ inch
	20 „	3½ inch	2¼ inch
	25 „	much set	
6.	16 „	2¾ inch	2⅛ inch
	20 „	Broken	
7.	15 „	2⅝ inch	1⅜ inch
	20 „	4½ inch	3⅝ inch
	25 „	much set	
8.	15 „	2⅜ inch	1 inch
	20 „	5½ inch	4¼ inch
	25 „	much set	
9.	15 „	2 inch	⅜ inch
	20 „	3⅞ inch	2⅛ inch
	25 „	Broken	
10.	15 „	3¼ inch	2 inch
	20 „	Broken	

From the foregoing experiments it appears that the elasticity sustaining power, and toughness of the English steel was much greater than that manufactured from the Swedish iron.

The *Laminated Spring* is the most common form for the springs of railway vehicles, consisting of a number of plates, the taper being given by reducing the plates successively in length.

The principle for regulating the taper of the spring is to obtain an equal amount of strain or deflection from each particle of material. If some parts of the spring are deflected less than others, the amount of material might be reduced in those parts without impairing the sustaining power of the spring.

A laminated spring may be tapered either in breadth or thickness, but if parallel in thickness and all the plates the same length, each plate should be uniformly tapered in breadth, so that each half of every plate would be a triangle. In practice the plates of laminated springs are made parallel in breadth and thickness, inasmuch as the parallel bar is the most economical form, and the taper is obtained, as before expressed, by the different lengths of plates.

If a spring consisted of only one plate, parallel in breadth but tapered in thickness, such taper should be in the form of a parabola, as the strength is in proportion to the square of the thickness. This form is shown in fig. 2, Plate IV, by the part AA.

Fig. 1 represents one-half of an ordinary wagon bearing spring. Fig. 2 is the same spring pressed flat, but supposing the plates not to slide over one another.

If the spring consisted of a number of very thin parallel plates, the correct form would be a uniform taper in thickness from the centre towards the ends, as shown by the portion BB in fig. 2, because the strength of each part of the spring would depend upon the number of plates at that part. In practice the most correct form of spring is between the two forms of the triangle and the parabola, but is nearer the triangle, as the thickness of the plates bears only a small proportion to the average length.

The spring shown in fig. 1 is 3 ft. 3 in. long, 3 in. wide, and 4$\frac{13}{16}$ inches thick in the centre, and consists of 15 plates $\frac{5}{16}$-inch thick, excepting only the outside plates, which are ⅜-inch, according to the usual practice, to allow for the plate not being supported by plates on both sides.

If this spring were a single plate of the same total strength it would be only 1¼ inch thick at the centre, and in the form of the parabola AA in fig. 2; but as it consists of a number of plates, the outline must be a line beyond that curve.

The straight line BB in fig. 2 is drawn outside the curve, giving a uniform taper from the centre of the spring to the end of the second plate, leaving the top plate its full thickness to the end. This line BB appears suitable to be adapted for the practical outline of the spring, as the deviation from correctness is only very small and gives a slight diminution in strength at the quarter length D, which is advisable in practice, because the centre C is usually weakened by a ⅜-inch rivet hole, reducing the strength one-eighth at that point.

The line BB is transferred from fig. 2 to the curved spring in fig. 1 by dividing the length of the top plate into 16 equal parts by the lines from 1 to 16, which are drawn vertical in fig. 2, and radiating to the centre of the curve of the spring in fig. 1. These lines being made of equal length in both cases give the curved line BB in fig. 1. The end of the top plate is lengthened and turned down at E to give a bearing to the spring.

The writer has in practice set out all springs required by him, by drawing through the extreme points C and E a circular arc of the same radius as the top plate of the spring. The line obtained by this method is a singular instance of how near practice has approached theory by this simple method, the extreme difference being only ⅛-inch.

The line HH is obtained in the same manner as before described, excepting that the spring is not tapered to the centre, but to a set-off of 2 inches from the centre, viz., from C to H. This is the form universally adopted, but it is clearly incorrect, as the centre is made proportionately weaker than the remainder of the spring, as well as being further weakened by the rivet hole through the centre.

The true and correct form of spring would be, that the centre of the spring should be at H, and the plates connected not by a rivet but with a narrow hoop. In practice the spring is clipped to and bears on the axle-box at H, and consequently the mass of steel H to C is entirely wasted.

In two plates of steel of the same length and breadth but of different thickness, the amount of deflection caused by the same weights is in proportion to the cube of the thickness, although the breaking strength is in proportion to the square of the thickness; consequently if one spring were made with plates double the thickness of those of another spring, the first would require only one-eighth the number of plates, viz., one-eighth the weight of material to support the load with the same amount of deflection; but in that case the extent of the displacement of the particles of the steel in the thick plates would be double of that in the thin plates, and in the practical application of thick plates to springs it is necessary to limit the deflection within the above extent, as the double amount of deflection would break or strain the particles, presuming that in the thin plates the particles were being strained to a reasonable extent.

The *Wagon Bearing Spring* in ordinary use on the Midland, London and North Western, and other railways is shown in fig. 1, and is 3 ft. 3 in. long, 6½ in. camber, 4$\frac{13}{16}$ in. thick. and 3 in. wide, consisting of 15 plates of which 2 are ⅜-inch and th rest $\frac{5}{16}$-inch thick, and the spring averages in weight about 93 lb.

This spring is used to sustain loads not exceeding 6 tons on the four springs exclusive of the wagon body; the wagon body weighs barely 2 tons, making the total load about 8 tons, or 2 tons per spring.

By actual experiments this spring deflects with

1 ton .... 2 tons .... 3 tons
⅞-inch .... 2 inches .... 3¼ inches

and will prove flat without setting or breaking. It is to be noted that in originally proving this spring flat it had set about ⅜-inch, but that with the same extent of proof it will not again permanently set, having this property in common with other materials. This spring would well sustain a load of 3 tons in actual work, as the concussions received upon the rails would probably not at any time increase the deflection ½-inch, consequently the load of 2 tons is being sustained on a spring far too rigid, to the detriment of the road and the wagon, and the original first cost is considerably more than it need have been. Formerly, various plans were adopted to lessen the friction at the ends of the springs by the use of rollers, but these plans are now obsolete, the amount of friction not being found practically detrimental. The points of the plates of laminated springs were formerly tapered in thickness, but now the usual plan is to form the taper in the breadth by cutting the plates at the ends in a triangular form. This method is found much more certain in its effect, is neater in appearance, and cheaper in manufacture. The cutting is generally performed either with the shearing machine or between dies in a punching machine, the scraps being used in the melting-pot for cast-steel.

Fig. 3 represents the *Wagon Bearing Spring*, or more correctly speaking, *prop*, in extensive use on the North Branch of the London and North-Western, the South Staffordshire, Caledonian, and other Railways, which may well be designated by the term *cheap*.

This spring is 2 ft. 5 in. long, 4 in. wide, 2 in. thick, camber 4 in. consisting of 4 plates ½-in. thick, and weighs about 40 lb. Actual experiment furnishes the following deflections—

1 ton .... 2 tons .... 3 tons
⅜-inch .... ¾-inch .... 1⅛ inch

The cause of the immense sustaining power of this spring has been explained before in the observations on thick and thin plates.

The writer has already endeavoured to explain that the ordinary spring (fig. 1) is too rigid; what therefore must be the wear and tear of rails, wheel tyres, vibration to the axles, and general wear and tear to the wagon and load caused by this rigid spring? Compared with fig. 1, this spring affords less relief in the proportion of 6 to 16, and is the furthest removed from the object required to be attained.

The *Wagon Bearing Spring* in extensive use on the Midland, Great Western, and other Irish Railways, and on the London and North Western Railway, is the ordinary spring as in fig. 1, but with eyes rolled at the ends and hung on scroll-irons. The advantages of this form of spring are the great space passed through and quickness of adaptation to the inequalities of the road, in consequence of the deflection of the end shackles caused by the deflection of the spring, and consequent elongation between the centres of eyes of shackles; also the rubbing friction at ends is almost entirely obviated. The disadvantages are, first, that to carry a given load a much greater quantity of material is required, as from the circumstance of a great portion of the space between the sole-bar and the axle-box being taken up by the scroll-irons and shackles, the radius of the curve of the spring is much reduced, and a thicker spring consequently required. Secondly, the tension on the sole-bars tending to hog the wagon frame, being the reverse of the action of the ordinary spring. Thirdly, in consequence of the great space passed through by the deflection of this spring, the variations of the load will considerably vary the height of the buffers from the rails.

Fig. 4 represents the now universal *Carriage Bearing Spring* originally introduced by Mr. Wharton on the London and North-Western Railway, as the result of repeated practical trials and improvements: theory would probably have never attained a similar result. This spring is 5 ft. 3 in. long, 3 in. wide, 2 13/16 in. thick, and consists of 9 plates 5/16-in. thick; the ends of the plates are what is technically termed long spear-pointed. Fig. 4 represents the spring when loaded, and the peculiar camber before fixing is made by setting the plates entirely at the centre, instead of the plates being set into a curve throughout their whole length as in other springs. In fixing this spring the tension-brace is adjusted between scroll-irons, with intervening compensating shackles. The tension-brace is 3 in. by ⅜-in. and thickened at the ends to ⅝-in. The spring is then compressed between the axle-box and the brace. The action of the spring and brace is that of a lever spring combined with a tension-brace, but the spring is so thoroughly overpowered by the leverage of the brace and the weight of the load, as to have little or no power of reaction or displacing the inertia of the load, beyond that of recovering its original position; thus affording the well-known smoothness and steadiness of action of this construction of carriage spring. The brace is acted upon principally at the point A, but nevertheless when the blow from the road strikes the point B, and the spring and brace straighten at that point, the curving and straightening of the brace at A is compensated by the straigtening and lengthening at C, the amount of tension at D being thus at all times about the same. The tension brace steadies and counteracts the power of the spring, and the spring partly relieves the brace by sustaining it at A.

This combination also affords the means of firmly attaching the axle-box to the spring and brace, and thus holding it independent of the axle-guards, which in this case are wholly *guards*, not *guides*, the guards neither touching the axle-box on the edge or side. Thus the effects of the inequalities of the road, laterally and horizontally, are only transmitted to the body through the elastic medium of the spring.

Springs of the same construction, but shorter and lighter, are now generally used for horse-boxes, carriage-trucks, and break-vans

Buchanan's Bearing Spring consists of four flat horizontal plates 4 ft. long, 4 in. wide, and tapered in thickness from ½-in. at the centre to ¼-in. at the ends, and fastened in the centre and impinging at the ends only. See fig. 5.

It does not seem to posess any advantage over the ordinary laminated spring, excepting that the friction between the plates is entirely avoided except at the ends; but at the same time it must be borne in mind that in ordinary laminated springs the steel is rolled concave, therefore the plates bear at the edges only, which very considerably reduces the friction.

The disadvantages of this spring appear to be, firstly, that the extreme points of support are when the spring is weighted considerably below the centre bearing, necessitating the use of deep scroll-irons in carriages and bearing-blocks in wagons.

Secondly, the manufacture is costly and uncertain, from the fact of the plates being tapered in thickness, and the difficulty of hardening and tempering plates that taper in thickness.

Thirdly, when fixed with scroll-irons the sustaining power is partly derived from its effect as a tension brace.

Adams's Bow-Spring, of the size used for passenger vehicles, is 6 ft. long from centre to centre of spring eyes, and the versed sine about 14 in. when weighted; the plates are 8 in. broad in centre and tapered in width to 5 in. at the eyes, and the thickness is 9/16-inch.

The advantages of this spring are, firstly, it holds the axle-boxes without the intervention of the guards in the same manner as previously described with reference to the carriage bearing spring. Secondly, that the top links permit the wheels, axles, and axle-boxes to traverse laterally in passing curves and other impediments. Thirdly, that the quick adaptation of this spring to lateral and perpendicular blows preserves the inertia of the body almost wholly from displacement at moderate speeds.

The disadvantages are, that at high speeds and on a bad road the reaction of this spring is so great as to cause a rebound, and the gradually increasing momentum from each successive blow occasions very considerable oscillation.

This property has completely negatived its use for 4-wheeled carriages; but it is now used successfully under the 8-wheeled carriages on the North Woolwich branch, and there works to considerable advantage, permitting the wheels to adapt themselves freely to the curves of the road. The oscillation is there almost obviated, from the fact that the blows are received upon eight points, and that the reactive power of a blow on one of the eight points is not sufficient to disturb the inertia of the load. This spring has been and is now used to a very considerable extent on 6-wheeled carriages in Germany; but it is to be observed that the speed on the Continent is generally slower than in England.

A *Spiral Bearing Spring* is represented in fig. 6, Plate IV. The dimensions of these springs as used under the tenders of the Midland Railway were 9 in. height and 6 in. diameter, and they were made of ⅞-in. round steel. Within this coil was fixed a second spiral of smaller diameter, coiled the reverse way to prevent the coils interfering. The action of a spiral spring is principally torsion of the steel bar through the angle A C B, and partly lateral deflection from the increase of diameter when the spring is compressed. Practically the writer is not well acquainted with the use of these springs, but presumes that the following objections have been found in practice: the spring bears upon the sole-bar at one point, viz. over the centre of the axle-box, instead of at two points some 3 ft. apart. There is a much greater uncertainty in the degree of elasticity and supporting power than in flat springs composed of many plates, partly from the greater thickness of steel causing uncertainty in the tempering, and from the greater angular strain on the particles of the steel; the sudden blows experienced by railway springs requiring the thickness of the steel to be within a certain limit, say of $\frac{3}{8}$-in. or $\frac{1}{2}$-in.

Buffer and Draw Springs.—The ordinary Laminated Buffer and Draw Spring is 5 ft. $4\frac{1}{2}$-in. long, $5\frac{7}{16}$ in. thick, and 3 in. broad, consisting of 17 plates, the outside plates $\frac{3}{8}$-in. thick and the remainder $\frac{5}{16}$-in.; the camber when at rest being 13 in. The same principles of construction apply to this spring as to the laminated bearing spring in fig. 1. These springs are generally fixed in the centre of the carriage, sliding between four bars of iron, ordinarily termed the "buffer spring cradle." The ends are acted upon by the four buffer rods, and the draw bar is cottered to the centre of the spring. The same methods have been tried to obviate friction at the ends as have been already mentioned with respect to bearing springs, but these plans are now obsolete. In fixing the springs on carriages they are generally compressed one inch, and in wagons to the extent of about one-third of the stroke. The stroke of the buffer rod is limited to such an extent as will not deflect the spring beyond a straight line. The sustaining power of this spring is equal to about 2 tons 14 cwt., or equal in all including both ends of carriage to about $2\frac{3}{4}$ tons, developed through a stroke of 2 ft. As yet this method of buffing has not been surpassed or equalled, as none of the modern substitutes will give this moderate amount of resisting power developed through so great a space as 2 ft.; also the weight of the buffer springs being in the centre of the carriage, and the springs acted upon by long buffer rods, cause the action to be very steady.

The *Double Draw Springs*, with a check bar to limit the action within the straining point, make probably the only truly effective method yet adopted. It is to be observed that the springs when drawn home are limited in their action by the check bar AA, thus forming a continuous rigid draw bar (see fig. 7, Plate IV). The springs are each 2 ft. long, $3\frac{9}{16}$ in. thick, and 3 in. wide, consisting of 11 plates, of which 2 are $\frac{3}{8}$-in. thick and the remainder $\frac{5}{16}$-inch; the camber is $3\frac{1}{2}$ in. before fixing; the springs are each compressed $\frac{1}{2}$-in. in fixing. The method of fixing is the same as already described for the laminated buffer spring.

External Buffers. Within the last few years a considerable number of external buffers have been introduced, consisting of a cylinder and piston packed with nearly every available elastic substance, and practically varying only in the material of the packing.

De Bergue's Buffer Spring is packed with rings of vulcanised india-rubber; there are 4 rings $5\frac{1}{2}$ in. diameter, and $1\frac{1}{4}$ in. thickness each.

In the opinion of the writer this is the least effective of any yet produced, as the stroke is very short, and then only moderately developed under enormous pressure. It is questionable whether in the event of a collision, the train would not collapse and leave the rails, before the immense sustaining power of these springs was fully developed. This buffer has an apparent stroke of about 3 in.; but it appears that to drive up the pair of buffers $1\frac{1}{2}$ in. would require a force of 3 tons. By reference to the description of the ordinary laminated spring it will be observed that the stroke is 12 in. with a force of $2\frac{3}{4}$ tons; being 8 times the length of stroke, with a rather less force. It is also questionable whether the vulcanised india-rubber is of that imperishable nature originally supposed. The writer has had in his possession a considerable quantity of vulcanised elastic bands for papers, that have become completely rotten.

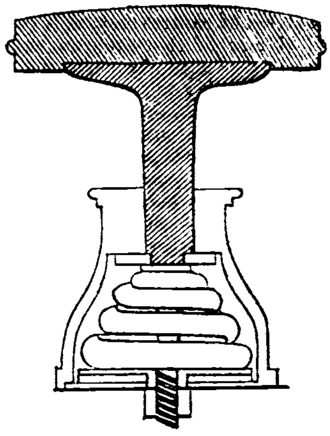
Todd's Cork Buffer is as nearly as possible the same as De Bergue's, excepting that the packing is cork; there are 5 plates of cork $7\frac{1}{4}$ in. diameter and $\frac{3}{4}$-in. thick each. This spring appears to be superior to De Bergue's inasmuch as the cork is more compressible than the vulcanised india-rubber, but it is questionable whether the cork is not liable to a permanent set.

Adams's Disc Buffer has the packing, consisting of 16 disc springs, made from flat circular plates of steel 8 in. diameter and $\frac{1}{8}$-in. thick, with a radiating piece AA, cut out to enable the plates to be pressed to a conical form (see fig. 8, Plate IV.) This buffer spring is superior to the foregoing inasmuch as the total amount of stroke is wholly developed, and the power can be properly adjusted by the thickness of the plates; the total length of stroke is $5\frac{1}{2}$ in.

Webster's Air Buffer exhibits considerable ingenuity, but is more complicated than the other plans. The air piston is 6 in. diameter, and the leather packing is distended by a vulcanised india-rubber ring; the length of stroke is 4 in. In the event of leakage during the stroke, the piston would not return to its original position, and to effect this a small spiral spring is employed which drives back the piston. A small valve admits air at the time that the piston is recovering its position to compensate for leakage during the stroke.

Spiral Buffer and Draw Springs are used to some extent, but they are liable to the same objections already described with reference to the spiral bearing springs.

Brown's Conical Spiral Spring Buffer appears to be the least objectionable of these (see the annexed woodcut). The resisting power is that of a spiral spring made in the form of a cone $7\frac{1}{2}$ in. diameter at the base, and the spring has the advantage of rotating at the point of the cone, thereby considerably easing the tendency to fracture or strain the particles of the steel; the steel is 1 in. wide and $\frac{5}{8}$-in. thick at the base of the conical spiral, and is tapered for the last three coils to $\frac{1}{2}$-in. diameter at the point of the cone. When driven home the spring forms a complete flat volute. The sustaining power of the spring is about equal for the space passed through to that of the ordinary laminated buffer spring, but with a shorter stroke, the length of stroke being only $3\frac{1}{2}$ inches, instead of 12 in. From its compactness and comparatively moderate price, it is in the writer's opinion, should the springs be found to stand their work, the most eligible of the external buffers; but yet far from equalling the result obtained by the use of the laminated buffer spring and buffer rods.



The whole of the cylinder and piston buffers are liable to the defect of the piston being guided through only a short length, and consequently they cannot work with the smoothness of the long buffer rod guided in several places. This more particularly applies in the event of an oblique blow upon the buffer.

In conclusion, it is suggested that it would be desirable for a correct table to be formed of the sizes, weight, sustaining power, and deflection of laminated bearing and buffing springs, as a uniform guide in their practical application.

Mr. Middleton remarked, that the conical spiral-spring buffer had been mentioned in the paper as the most advantageous of the external buffers in respect of the length of stroke, but that a still greater length of stroke was required; and he wished to mention one that he had introduced, consisting of a double-coned spiral spring, which had the advantage of giving a greater length of stroke, and he thought would form a very satisfactory buffer. They had been applied for the purpose of making a long buffer of 7 feet stroke, by using 6 of these springs, 4 in the middle and 1 at each end of the buffer rod.

Mr. Adams observed, that an objection to the double-coned spring would be that it was not free to revolve on its axis like the single-coned spring whilst it was being compressed, because it rested on the large base of the cone at each end, and the friction would be too great to allow of its revolving, but the single-coned spring had so little friction at the small end that it was capable of revolving when compressed. The strain on the steel was much increased if a spiral spring was prevented from revolving when compressed, and it was consequently more liable to break.

Mr. Fuller wished to state (for Mr. De Bergue in his absence), with respect to the vulcanised india-rubber in buffer springs, that upwards of 100,000 of the rings had been sent out, and many of them had been in use for two or three years; and as far as he had ascertained, the cases of failure had been very few indeed. In some cases where the material had been used for bearing springs, it had failed in consequence of not having a sufficient amount of bearing surface, but in the application to buffer springs he was not aware of any instance of failure excepting in a few cases where the rings had been over vulcanised.

Mr. Adams replied, that he had not had any experience of the durability of the vulcanised india-rubber applied to buffers, and he had therefore only stated the circumstance he was acquainted with of the bands for papers.

DETERIORATION OF RAILWAY AXLES.

(*With Engravings, Plate* IV.)

On the Deterioration of Railway Axles, &c. By Mr. J. E. McConnell.—(Paper read at the Institution of Mechanical Engineers.)

Having been requested at the last meeting to furnish further proofs of the change from the fibrous to the crystalline character produced in railway axles, and feeling convinced that a strict and careful examination of this important subject is a *necessity* in this age of railway practice, the inquiry has been resumed in the hope that the further information and experience gained may tend to a more perfect knowledge of the subject.

Before stating the results of the different experiments which have been made with the view of ascertaining the cause and extent of the change from the fibrous to the crystalline appearance in railway axle iron, it must be observed that in this, as in some other matters of controversy, it is most difficult to produce full and conclusive proof that the iron which is produced of a crystalline character was once fibrous, as we cannot by any experiment show the change visibly taking place; but surely it is fair and reasonable to admit the *fact* of a change, when we find railway axles when new, from the particular mode of manufacture, present through every part of their substance a tough, strong, fibrous appearance, yet, after several years' use, we find axles of the same description, owing to the various deteriorating causes in action, break short at the back of the wheel, and then present an appearance totally different from the original structure of the iron, as described above.

It has so happened, in strong confirmation of the views stated by the writer at the former meeting, that a very remarkable instance of this change was brought under his notice shortly after the discussion; and he thought the evidence which this case furnishes so important and conclusive (although produced without any design, and in the ordinary course of business), that the axle has been brought for the inspection of the present meeting.

This axle was fixed in cast-iron wheels, of the pattern in use on several lines of railway, having the H-form of spoke, and, as this wheel is perfectly rigid, experience has proved that the axles are much more liable to deterioration when working in these kind of wheels than in those wheels made partly of wood or other construction of wrought-iron, &c., which may have a certain amount of elasticity.

The axle now under consideration broke, in ordinary working, close at the back of the wheel, as is usually found; and the fractured ends, which are now produced to the meeting, afford the most distinct proof of the annular space which was stated on the former occasion to be observable all round the surface of the fracture; and this is not only short-grained and crystalline, but there is also, in the writer's opinion, an evident distinct separation to the extent of the annular space, which it would appear takes place some time before the final fracture, as if each successive blow, heavy or light, lateral or vertical, received or transmitted through the wheels, had each tended to destroy its proportion of cohesion of the previously crystallised substance of the axle at that particular place where the fracture occurs.

On receiving this axle in the workshops, with one wheel still attached, it was allowed by accident to fall a short distance from the wagon to the ground; and so brittle had it become next the wheel that the other end snapped off simply from the effect of the fall, and shows, as will be observed, a precisely similar appearance to the original fracture.

The writer was anxious to ascertain how far the theory which he held was correct, that the deterioration of the axle was principally local at that point (the back of the wheel), and for this purpose he caused the centre of the axle between the two fractures to be laid on supports, with the view of breaking it. A weight of cast-iron weighing 17 cwt. was then allowed to fall upon it through a space of 14 feet, but after several attempts it was found to make no impression upon this centre part of the axle towards effecting a fracture, although it was a frosty day, which would of course render the iron more brittle. Finding all efforts to break it by blows fruitless, the axle was then, in order to test its fibrous character, taken to the hydraulic press, and it has been bent to the form of the letter U, until the two ends met, without showing more than the slightest appearance of the skin of its surface breaking, as will be seen, proving still to be of a strong fibrous iron in the centre of the axle. See fig. 9, Plate IV.

Following up his proposition, the writer wishes to lay considerable stress on the view he previously stated, respecting the effect of the blows or vibrating action given through the wheels to the axle; he attributes the crystallisation of the axle at that point close behind the wheel, to the sudden stoppage or reaction of the vibratory wave at that place, owing to the check which it meets from the mass of matter consisting of the wheel, &c., presenting a break of surface, and acting more as an anvil, causing the vibration to react like a blow on the neck of the axle (the nearest weakest point), thereby destroying its fibrous character.

Cast-iron wheels, therefore, are objectionable from their rigidity and non-absorption of the lateral and vertical concussion with other strains formerly enumerated, received in course of working, and transmitted to be wholly expended on the axle; and the writer endeavoured to illustrate this by a comparative experiment with two different axles of the same description and age, one being fixed in cast-iron, and the other in wooden wheels, those known as the Pimlico make.

1st Experiment was made on the axle with wooden wheels placed horizontally resting upon the rails; a weight of 17 cwt. was allowed to fall through a distance of 13 ft. 3 in. upon the axle, immediately within the wheel, by which the axle was slightly bent at the point where the blow came, and a portion of the tyre resting on the rail was broken clear out. This experiment was repeated four times on the other end of the axle, which was bent but very slightly, and the wheel was rendered completely useless.

2nd Experiment was made upon the axle with cast-iron wheels, placed as in the former case, and the same weight was allowed to fall the same distance at the back of the wheel, when the effect of the first blow was to break the axle at the other end, at the back of the wheel; thus proving that in the former case the axle was saved from fracture by the wooden wheel absorbing its full share of the effect of the blow, and the tyre of the wheel breaking proved that in course of working it would receive a portion of the deteriorating forces tending to crystallise, the wheel acting like a cushion to soften the blows before they reached the axle; in the latter case the rail supporting the cast-iron wheel was fractured in three places.

A 3rd Experiment was tried with another axle with cast-iron wheels placed as before, and received *four* blows on each end of the axle within the wheels, which caused it to bend, but produced no fracture. This axle had not been much used, and was of a stronger fibrous character.

In order to ascertain the relative appearances of axles which had been in use, and determine the position of the crystalline change, both at the centre and outer surface of the axle, the writer caused four axles which had been condemned as too small from wear in the bearings, to have a groove cut in two cases on each side, to within an inch of the centre, and in the other two, grooved through to within an inch of the outer surface; these were split asunder with wedges, and their appearances will show that a certain change has been going on, and this is more observable in one end of the axle than the other, attributable, he believes, to the break being applied to the wheel which was on the end where the greatest crystalline change is visible.

He has made a number of other experiments in the presence of several of the members of the Institution, with the view of determining the effect produced on the fibre of iron by the cold hammering process. The following are the principal results:—

No. 1. A piece of ordinary bar-iron $2\frac{1}{2}$ inches wide and $1\frac{1}{8}$ inch thick, received 20 blows to nick it across, and was broken with 21 blows of a 14 lb. hammer, showing a fracture part fibrous and part crystalline.

No. 2. The same bar received 52 blows on one side, and 55 on the other, from the 14 lb. hammer, with 20 to nick it as before, and it broke with 14 blows, showing different layers of fibre and crystal.

No. 3. The same bar received 50 similar blows on each side as No. 2, but each blow on alternate sides successively, and 20 in nicking, and 9 blows broke it.

No. 4. The same bar was not cold-hammered, but received 20 blows in nicking, and required 28 blows to break it, showing a good fracture.

No. 5. Was a $\frac{7}{8}$-inch square bar, received 50 blows on each of two opposite sides, and 25 on each of the other sides, with 4 blows in nicking, and 5 broke it.

No. 6. Without any cold-hammering and the same bar, after receiving 4 blows to nick, required 6 to break it.

No. 7. The same as in the case of No. 6, had no cold-hammering, with 4 blows to nick it, and required 30 blows to break; in this case it was broken the flat way of the pile of the iron, but in No. 6 it was broken the edge way of the pile.

No. 8 Experiment was made on a shaft $3\frac{3}{8}$ inches diameter, which was cold-hammered at one end, having received 204 blows on all sides from a 3¼ ton tilt hammer; 110 blows with a sledge hammer were given to nick this end all round which had been cold-hammered, and it required only 5 blows from a 3¼ ton hammer to break it; the other end which had not been cold-hammered, after receiving the same number of blows in nicking, required 78 blows under the 3¼ ton hammer to break it, thus proving the enormous amount of deterioration of the strength of the iron caused by the cold-hammering process.

No. 9. A piece of round iron 2⅜ inches diameter which had two bearings turned (one at each end) 1⅞ inch diameter by 2¼ inches long, was allowed to run at a considerable velocity for about an hour, with one end oiled and the other dry, the dry end being cooled with water repeatedly when it became hot; the iron was then experimented upon in order to determine by the different force required to break the end which had been injured by want of lubrication, the relative strength of each bearing, but such was the remarkably tough quality of this iron, that although it received 320 blows of a heavy sledge hammer in every possible way to break it in one direction (without being nicked), no fracture could be effected, but the iron seemed to be drawing out at the back of the journal on end, as will be seen by the meeting.

This last case is noticed in particular, as the following experiment of a similar character with an old axle of larger dimensions, shows in strong contrast the altered nature of similar iron from use on a railway, owing to the jar or vibrating action it has suffered.

In the 9th experiment a piece of new iron intended for part of an axle, although run dry and cooled with water, yet was so fibrous, having received no jar, that it resisted all effort to break it.

No. 10. Another experiment of a similar character was tried on an old axle which had been a long time in use, of the same kind of iron and manufacture as the bar in No. 9 experiment. This axle with the wheels on was run in its own bearings in a lathe at a velocity equal to 10 miles per hour for 5 hours; one journal was kept running dry, and when heated by the friction cooled with water, while the other journal was kept well lubricated with oil. When taken out, the journal which had been heated was broken with 12 blows of a hammer 22 lb. in weight, while the lubricated journal required 91 blows with the same hammer to break it, in both cases without being nicked; this appears satisfactorily to prove the injury to the axle which results from the practice of throwing cold water on the journal to cool it when it has become nearly red hot from want of proper lubrication.

In addition to various other experiments with the view of determining the change which is gradually going on in railway axles, and other iron liable to a jarring, vibrating motion, the writer would refer the meeting to a few samples of broken axles sent to him from various quarters, which, if proof were wanting, completely substantiate, in his opinion, the certainty of the crystalline change.

Before reading some of the communications received from other gentlemen containing their experience on the subject, he would first call attention to the two experiments which were tried in relation to the proportion and form of axle, in order to meet the objection raised at the former meeting, "that the slow pressure on the flanches of the wheel to discover where the axles were most exposed to the bending strain was not a faithful representation of what takes places in practice." The axle was fixed upright, so that the wheels were placed in such a position that the violent blow when the wheels of the carriage jarred upon the rail was fairly represented by the blow caused by the descent of a weight of 17 cwt. which was allowed to fall upon the edge of the wheel at A, from a height of 9½ feet. It is most satisfactory to find that the curve into which the axle was bent, is quite in accordance with the former results, which were obtained by slow pressure applied at the same points, and establishes the rule of proportion of the axle therein stated. See figs. 10 and 11, Plate IV.

The following are some instances of tough fibrous wrought-iron being rendered brittle and breaking off quite square with a close-grained fracture from the effect of the concussion of very small blows rapidly repeated for a long period; the blows being very small in force compared to the strength of the iron. These specimens are from the machines for making button shanks, in Mr. Heaton's Mills, Birmingham. The hammer in these machines is about 2¼ lb. weight, and is lifted by a rod ⅜-inch square, which has a pull upon it of about 12 lb. from the difference of leverage; the hammer strikes 120 blows per minute, but the cam that drives it acts only during one-fourth of its revolution, so that the velocity of the hammer is equal to four times the number of blows, or nearly 1000 changes of motion per minute. The lifting-rods always break with a close-grained short fracture, although made of the toughest and most fibrous iron that can be obtained, and they sometimes last only a few months; the rods break near to the end, which is fixed with a coupling, and the deterioration of the iron appears to be confined within a small portion, the iron remaining quite tough and fibrous within an inch of the fracture, as shown by the specimen, which has been bent double at that part. The hammer is snatched suddenly by the lifting-rod, and is pulled against a strong spring for the purpose of getting a quick recoil and a sharp blow of the hammer, much quicker than it would fall by gravity.

Another specimen from the same machines is the lever for pushing off the work from the machine when stamped; the lever is about ¼-inch square, made of the toughest wrought-iron, it is 9 inches long, and falls back against a stop at one-third of its length from the centre of motion at the bottom, being thrown back sharply by a spring, the total strain upon the lever varying from about 1 lb. to about 12 lb., according to the accidental circumstances in the working of the machine. These levers all break off quite short and close-grained within an inch of the part that strikes against the stop, but the iron continues quite fibrous and unchanged to within an inch of the point of fracture, as shown in the specimen. They were driven at the same speed as mentioned above, amounting to nearly the velocity of 1000 changes of motion per minute; but they broke so frequently, lasting sometimes only a few weeks, that it was determined at last to reduce the speed of the machines from 120 to about 100 blows per minute, and in consequence of this reduction in speed the levers are much less frequently broken, and last on the average about four times as long as before.

Communication from Mr. John Kekwick:—

> "*The Holmes, Rotherham, 4th December*, 1849.
>
> "I have been reading in the *Mechanics' Magazine* for last month a report of your able paper on railway axles, and I notice Mr. Robert Stephenson said that Mr. McConnell had expressed a strong opinion that a change took place from a *fibrous* structure to a *crystalline* one during the time of its being in use, and it would be satisfactory if an instance could be pointed out where this change had occurred owing to vibration or other treatment, &c, &c.
>
> I think I can furnish an instance in proof of your opinion on this point:—In one of our forges we are daily in the habit of using a metal helve or hammer weighing about 4 tons, for the purpose of drawing large sizes of steel, and the shaft of this helve is 17 inches by 9 inches. Finding great inconvenience and danger from the breakage of *cast* iron helves, we were induced to try a *wrought*-iron one 16 inches by 8 inches. After using this for several months, the shaft broke in two about the middle, and the fracture presented a crystalline appearance of 'short' cast-iron: we repaired the shaft, and in the course of a few months it again broke about the same place, and it again presented a similar granulated, cast-iron like, crystalline appearance throughout the face of the fracture. I attributed this change solely to the *vibration* and *jar* occasioned in the process of hammering steel, more particularly *cast*-steel."

Communication from Mr. Benjamin Gibbons:—

> "*Shut End House, near Dudley*, 15*th January*, 1850.
>
> "When the heavy cast-iron helves were used for drawing out bars, and the art of *chilling* iron was little understood, the nose or that part of the iron helve struck by the cam to lift it was protected by a wrought-iron plate well fitted, and this was secured by a large pin countersunk into it, and extended through a hole cast through the nose of the helve, and screwed as fast as possible on the upper side. The very best and *most fibrous* iron (ascertained to be so by previous breaking) was always selected, and yet when the pin broke by the repeated shocks it had to sustain (about 90 times per minute), it always broke with a large bright grain, *without the least trace of fibre*. This was so regularly the case that I never knew a pin last for many months.
>
> Another instance was in a fly-wheel where wrought-iron arms were used instead of cast-iron, for the purpose of throwing the weight to the outer circumference, and this wheel was applied to a forge-hammer engine. It worked well for a time till the arms got loose in the cast-iron rim, and then a violent shock was received every time the cam struck the helve; after some time, the arms began to break one after the other, and though the iron was of the toughest description originally, it was found that any part broken was of a bright crystalline grain.
>
> The pins of shears for cutting down large cold bars sustain violent shocks; they perpetually break with the same bright grain, though made of the toughest iron. Also the iron arms of common carts always break with that grain from the same apparent cause.
>
> I have taken iron of this bright crystalline character which I had previously known to be fibrous, and by drawing it down a little at a proper heat have never failed to restore the fibrous texture of the iron."

The practical suggestions derivable from the foregoing experiments and inquiries, which are confirmed by all the writer's previous experience and information, are—

1st. That the axles of all railway engines, carriages, and vehicles should be made of the best ascertained quality of iron for the purpose, both tough and strong, and of uniform clean fibrous texture.

2nd. The proportion of an axle in all parts to be determined from sound experience and calculation; the load it has to carry, the speed at which it is run, and the description of wheel in which it is placed, and strains to which it is liable in working from curves or inequalities of the road, or other deteriorating causes, being fully considered.

3rd. That previous to any axle being allowed to run on any line, the maker's name should be legibly marked thereon and the date of manufacture, and also when it was first put to work. It is of course manifestly impracticable to record the number of miles run; but as all railway stock in a general way is worked nearly uniform, the above particulars would afford the necessary data to guide the opinion which may be formed of the age beyond which limit the iron becomes comparatively unsafe.

4th. That it be part of the duty of the proper officer to see that all axles are working in good condition and receiving careful treatment.

5th. The next point the writer would press is, that all in whose power is the opportunity for registering facts in connection with railway axles, should by this, or some recognised scientific Institution, be requested to note and carefully collect their information on all points, in order that a certain average result for the guidance and benefit of all interested may be arrived at.

6th. That attention should be given to ascertain the description and working condition of wheels which in all points cause the least deteriorating effects on the axle; and for this he proposes to produce some further experiments and also results from practice.

7th. That the quality of lubrication and description of bearings used should also be considered; and for this he also proposes to give a paper to the Institution, with the results of experiments and experience.

It is obviously of most material advantage to all who are connected with or have the management of machinery, whether for railway, manufacturing, or mining purposes, to have their attention directed to the phenomena bearing upon the nature, use, stability, and durability of the iron or other material of which that machinery is constructed; as it must be manifest that we must first obtain a clear knowledge of the best quality, the best form, and the best treatment necessary to select and prepare it for use, and to preserve it from any deteriorating causes as far as possible, in order to obtain the greatest safety, efficiency, and economy in working the machinery for the purpose it is intended to effect.

With the above views kept prominently before them in all their inquiries in this as well as in other branches of practical research in developing improvements of commercial utility, the members of this Institution, from their different positions, with large and varied opportunities, will be enabled to effect great good; they will assist the progress of useful mechanical inventions, and entitle themselves to the respect and gratitude of all classes, as being the means of producing and encouraging lasting and substantial advantages to the commercial and manufacturing interests of the country.

Remarks made at the Meeting after the Reading of the foregoing Paper.

The Chairman (Mr. McConnell) remarked, that it was much to be regretted that their President, who took a great interest in the subject, was absent, and perhaps it would be well not to conclude the investigation that evening, in order to afford him an opportunity of being present.

Mr. Cowper inquired with reference to the broken axle exhibited, whether it had been nicked to a square shoulder and broken to test the quality of the iron, or whether it had only been bent by pressure?

The Chairman replied, that the axle was broken at one end whilst running on the railway, and was broken off short at the other end by falling to the ground; and then in order to see whether the crystallisation was local or otherwise, it was afterwards bent in the centre by three or four blows from a weight of 17 cwt., falling upon it, without the axle being nicked, and it was then doubled up by the hydraulic press, but it did not show any appearance of breaking.

Mr. Wright observed, that the fracture was at a very deep square shoulder, and a great deal of the appearance round the fracture might be the result of the shoulder.

The Chairman replied, that this to a certain extent might be the case, but even without the shoulder there seemed to be an annular crystalline space going on forming.

Mr. Walter Williams expressed his full concurrence in the views stated by Mr. Gibbons in his communication, which were founded on very long experience. He could also speak from the experience of many years, that he had invariably found that iron much used as axles broke in the manner described by the Chairman. He was therefore quite satisfied that a change takes place in the structure of iron, and was rather surprised that a different opinion was entertained, because he had observed hundreds of instances where after having produced a good tough fibrous iron, yet after hammering it had broken crystalline. But to show how well it was known that iron was affected in structure, he would mention that in making iron for particular purposes it was desirable to have it of very close fibre, and it was customary to throw the hot iron into a water bosh in the state in which it came from the rolls, and that injured its fibre. The object in thus dealing with the iron was to clean it, and when next put through the rolls its fibrous character was restored; hence he was of opinion that in the case of axles deteriorated by wear their fibrous character might be restored by drawing down hot, for there was no doubt it was the action of the wheels which made the change.

Mr. Hodge considered the subject as one of great importance, and suggested that the discussion should be deferred until after the members had been furnished with a copy of the paper and the experiments, with such diagrams as were necessary for their illustration. So important was the question which presented itself with reference to changes in the structure of iron, that it had occupied the attention of the American Institute for two sessions, and he thought that this Institution should not allow the subject to pass without a long and careful consideration, because it was necessary to have regard to the various circumstances under which the iron was manufactured, and the particular character of the iron itself.

Mr. Henry Smith, in reference to his promise at the last meeting to furnish some results at the present meeting, observed that the experiments on cold-hammered iron, which were described in Mr. McConnell's paper, had been tried at his works, and he fully concurred in all that Mr. McConnell had said with reference to them.

Mr. P. R. Jackson inquired which class of iron the chairman considered best for railway axles—malleable iron or steel? For his own part, when he required great strength he employed good steel, and found that answer the best.

The Chairman, in reply, repeated the first practical deduction contained in his paper—viz., "that the axles of all railway engines, carriages, and vehicles, should be made of the best ascertained quality of iron for the purpose, both tough and strong, and of uniform clean fibrous texture." That was his opinion with reference to the quality of iron to be employed; and he thought the Institution would be departing from its province were it to consider any particular district or manufacture. They were now treating of the *deterioration of railway axles*, and the question to be decided by proofs adduced to the members was whether they underwent such a change as from fibrous to crystalline iron; that question being determined, they might then not only consider the quality of iron, but the form of railway axles most advantageous to be adopted.

Mr. Hodge observed, that when steel was employed it was in order to produce stiffness and not to resist torsion; he did not think that the mere imparting of carbon to iron would give it the properties required for the present purpose.

Mr. Slate doubted whether the term fibrous, as applied to iron, properly described the state or condition of the material to which it referred. He could understand a fibre of cotton or wool, or other such material, but in the case of fibrous iron, as it was termed, they found a series of small crystals united longitudinally, giving the appearance of fibre; and when that changed to larger crystals the peculiar cohesion seemed to be destroyed, and the whole became a conglomerate mass without any appearance of fibre.

Mr. Cowper said, it appeared to him that fibre in iron was composed of the separate particles of iron existing in the puddling furnace of different sizes, and that these were afterwards elongated in the process of forging and rolling, so that a number of long particles were obtained lying near to each other, though there was not perfect contact, owing to the interlying cinder. Crystalline iron was that in which the particles assumed any other form than the elongated form. All iron contained a portion of cinder or silicate of iron, which was more or less squeezed out in the process of forging and rolling.

Mr. Hodge remarked, that to arrive at any true results as to the structure of iron it would be necessary to call in the aid of the microscope, to examine the fibrous and crystalline structure.

Mr. Walter Williams adverted to the well-known fact that the continued working of machinery, such for instance as the crank pins of engines, destroyed the fibrous structure of the iron and made them crystalline.

Mr. Cowper remarked, that it was his opinion that iron could not become crystallised unless it was hammered or so strained by force as to alter its form and produce a permanent set or change of form; he did not think however that an iron railway axle became crystallised from the action of the concussions of the wheels; because he did not think that the effect produced was equivalent to cold-hammering; he thought a fair experiment would be to turn a square shoulder in the centre part of the broken axle which had been bent up by pressure, and then to break it with a nick at the shoulder, and see if it broke with a fibrous or crystalline fracture, for it was well known that by nicking iron it would break more crystalline.

Mr. Hodge illustrated the subject by reference to the effect produced upon the journal of a picker shaft in a cotton mill, at Lowell in America, where in order to produce stiffness a shaft of cast steel was introduced, but it frequently broke off at the journal, particularly when there was a very tight belt on the drum. A collar of cast-iron 1⅛ inch thick was then shrunk on the journal working in a brass bearing, and it then worked well. He merely adduced this fact to show that the friction caused by high velocity produces a change in the molecular structure of iron.

Mr. Hoby did not think that from the mere appearance of the sectional fracture they could exactly determine the molecular change. They would recollect that Mr. Stephenson adverted to some experiments by Mr. Brunel, where from the mode of producing the fracture the same bar of iron gave out different results; these experiments were perhaps conducted on too small a scale to furnish undeniable results, but he thought it quite possible that the same bar of iron should exhibit different results when twisted slowly in a vice or struck by a smart blow; in the one case the fracture might be crystalline, but fibrous in the other.

A Member said that he had tried an experiment with very tough charcoal iron; he merely attached it to the head of a tilt hammer, which went about 300 strokes per minute, and after a few weeks it broke off brittle without any blow, although the iron was at first as tough as it could be made; and this was attributed only to the jarring.

Mr. Hodge observed, that this was quite analogous to the results given in the report of the Commissioners on the experiments with reference to the duration of wire bridges in France, that the effect was produced by the constant vibration or jarring between the particles of the iron.

Mr. William Smith said, that he produced two specimens of ordinary puddled-bar iron 1⅛ in. square, on which he had tried the effect of hammering; the first piece was broken off from the bar by 22 blows of a 14 lb. hammer, the bar having been nicked, and the fracture was very fibrous; the second piece was 7 in. length cut off from the same bar next to the first piece, and he set it on an anvil and struck it 20 blows on the end, and it was then nicked in the middle and broke off with a single light blow, and showed a square crystalline fracture; another piece was then broken off the same end of the bar as the first piece, to ascertain if the quality of iron in the bar was the same, and it required 21 blows to break it, and was similar in the fracture to the first piece.

Mr. Middleton remarked, that in taking off the tyres from the driving wheels of an engine he observed that the bolts were quite crystalline; he was quite satisfied there was a change. And with regard to the hammering which took place on the rails, in his opinion, it was quite sufficient to cause the change observed in railway axles.

Mr. Heaton said, he fully concurred in all that had been said in favour of a change being affected in the structure of iron. He considered the change was generally confined to some particular part, and the rest of the iron was not injured; in his machine for flattening button shanks, which gave a blow of about 12 lb. (mentioned in Mr. McConnell's paper), the constant action had the effect of breaking the levers, which showed a crystalline fracture, although within half-an-inch from the part so broken the iron continued unchanged and quite fibrous. The same was observable in the cross pins of corn-spindles which frequently broke in a few weeks' wear; and he did not know which lasted the longest, steel or iron, but he thought good scrap iron would last as long as a piece of steel, but it would not last half the time if subjected to cold swaging. In the example he produced of broken cross pins, the fracture showed a vertical division, because the strain was only at each side; but in the case of a railway axle the fracture showed a circular space in the centre, because the strain was all round the axle on all sides in succession.

The further consideration of the subject was then adjourned to the next meeting, and the Chairman said, he hoped the members would come forward with all the information they could collect which bore upon a question of such importance; and for his own part he would take every opportunity of trying farther experiments and collecting facts with reference to it.

Coating Ships' Bottoms.—A patent has recently been granted to Messrs. A. Yule and J. Chanter, for improvements in coating ships' bottoms with one or other of the following compositions:—First, 8 to 10 parts of bullock's-gall, 30 lb. of carbonate of iron or plumbago reduced to a fine powder, and mixed together to form a paste, to which 4 gallons of salt water are to be added to bring the whole to a proper consistence. [What relation is there between parts and pounds?]—Second, 30 lb. of carbonate of iron or plumbago in powder, 3 lb. of white arsenic, 2¼ gallons of coal tar, naphtha, or spirits of turpentine, and from 12 to 14 lb. of Stockholm tar.—Third, 10 lb. of carbonate of iron or plumbago in powder, and 1 lb. of white arsenic, to which Russian tallow is added, with the assistance of heat to incorporate the whole. This composition is to be applied hot, and rubbed over with the dry powder.

DWELLINGS OF THE LABOURING CLASSES.*

On the Dwellings of the Labouring Classes. By Henry Roberts, Esq.—(Paper read at the Royal Institute of British Architects, Earl de Grey, K.G., President, in the Chair).

The subject to be now submitted to the consideration of the Institute of British Architects is one to which their special attention has not been previously invited, although it was incidentally alluded to by my friend, Mr. Smirke, in the course of the last session.

Much has lately been said and written on the dwellings of the labouring classes; our illustrious patron, the Prince Consort, has emphatically shown that he feels deeply interested in this subject, and has publicly announced that "these feelings are entirely and warmly shared by her Majesty the Queen," our most gracious patroness. Still it is probable that but few members of the Institute have given any special attention to those details which will be brought under your notice; and certainly a yet more limited number have been professionally engaged in a field of labour, which apparently offers little scope for scientific skill, and but few attractive points to an artist's eye. Such was my own case when, between five and six years since, I undertook the duties of Honorary Architect to the Society for Improving the Condition of the Labouring Classes, to whose operations in this department your attention will be hereafter invited.

There appear to be many reasons which, in an especial manner, commend this subject to the consideration of the architect, besides those which give it so strong a claim on the serious attention of the philanthropist and political economist. A moment's reflection must show that the highest achievements of architecture are accomplished through the instrumentality of the working classes, whose skill and persevering industry conduce as much to the fame of the Architect as the steady valour of the soldier does to weave the crown of victory around the brow of his triumphant General.

We shall not enter into a lengthened detail of the present state of the dwellings in which a very numerous body of the labouring classes are lodged. Personal observations most fully confirm what has been stated over and over again as to the magnitude and wide extent of the wretchedness resulting from their actual condition, arising, as it does, from the want of all those arrangements which are calculated to promote the comfort and moral training of a well-ordered family, as well as the utter absence of proper ventilation, efficient drainage, and a good supply of water; together with a system of overcrowding that would not be tolerated for the domestic animal in the farm-yard, the stable, or even the dog-kennel. One example may suffice. About four years since, with the desire to obtain ocular demonstration as to the actual existence of such a state of things, I visited with a friend several houses in the immediate neighbourhood of the Model Lodging House, George-street, Bloomsbury, to be hereafter described. In one of these houses was a room about 22 feet by 16 feet, the ceiling of which could be easily touched with the hand, without any ventilation, excepting through some half-patched broken squares of glass; here were constantly lodging from forty to sixty human beings, men, women, and children, besides dogs and cats. Further detail it is unnecessary to describe; their very recital would disgust you.

If it be said that the remarks just made can alone apply to a metropolitan St. Giles's, or to Saffron-hill, a reference to the valuable reports of the Health-of-Towns' Commission, or to the more recent and graphic descriptions in the columns of the *Morning Chronicle*, will abundantly show that our provincial towns, our rural villages, and even many of the picturesque cottages which so much enliven the landscape of Great Britain, form no exception to the wretched condition of a large proportion of the dwellings tenanted by our labouring peasantry, artisans, and mechanics. In a provincial town, I lately entered one of three cottages approached by a passage 2 ft. 6 in. wide, common to the whole of them; in a ground-floor room, 10 ft. 6 in. by 8 ft. and 5 ft. 10 in. high, with a triangular loft in the sloping roof, were lodged a husband, wife, and five children. The out-buildings common to these cottages I forbear to describe. Yet this is an underdrawn picture of the domiciliary wretchedness which many a dwelling in England, with its boasted civilisation, refinement, and wealth, presents. Some have only one room, occupied by a great number of inmates; some have three or four rooms, each occupied by a distinct and often numerous family; in some cottages, one or more

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* This Paper has been printed in full in a pamphlet, together with several wood engravings and lithographs of Dwellings for the Labouring Classes, which is well worthy of perusal. It is published at 2s. 6d., for the benefit of the Society.

lodgers occupy the same apartment with the family, regardless of age and sex.

The practical view of the improvement of the dwellings of the labouring classes which it is desired to bring under consideration, will be most conveniently taken by first pointing out the general principles applicable as well in towns as in the country, and afterwards by considering these two descriptions of dwellings separately.

The most humble abodes, whether in a town or in the country, in order to be healthy, must be dry and well ventilated; to secure the former, it is essential that due attention be given to the situation or locality, to the foundation, and to the drainage, as well as to the material of which the external walls and roof are constructed. To secure ventilation, there must be a free circulation of air; a sufficient number and size of openings, and adequate height of the rooms, which I should fix at not less than 7 ft. 6 in. to 8 feet.; in town buildings I have allowed 9 feet from floor to floor. The area of the apartments should be in proportion to the probable number of occupants; where intended for families, the living room ought not to contain less than 140 feet to 150 feet superficial, and the parents' bed-room should measure at least about 100 feet superficial; in the latter it is of importance, as a provision for sickness, that there should be a fireplace. In every room an opening for the escape of vitiated air ought to be made near the ceiling, especially in the smaller bed-rooms for children, where there is no fireplace. An entirely satisfactory system of ventilation, applicable to small apartments—by means of which the vitiated air shall be removed, and an adequate supply of fresh air be introduced, without causing any perceptible current,—appears to be still a desideratum. My experience is certainly unfavourable to the *indiscriminate* use of chimney valves fixed in the ordinary manner. In some cases, they answer perfectly; in others, it is almost impracticable to prevent the ingress of smoke through the aperture; on this account I prefer, where practicable, carrying up for some height an independent ventilating flue, which may be 9 inches by 4 inches or even smaller, and ultimately open into the chimney flue, or into the external air if there be no chimney flue from the apartment. The most simple and economical ventilator for the admission of external air which I have tried is fixing in an aperture behind an air brick an iron frame fitted with a sheet of perforated zinc, and having an iron plate hung to close it with a rack. Perforated ventilating glass and Bailie's sliding ventilators are both valuable inventions.

For the comfort and health of the inmates of every tenement, the protection afforded by an internal lobby or close porch is of importance, as well as the relative position of the doors and fireplaces to the living room, which should be so arranged that there may be at least one snug corner free from draught. Where casement windows are used, the great difficulty which is found in the lower class of buildings of rendering them weather-tight, renders it desirable that they should invariably be made to open outwards, and be properly secured by stay-bar fastenings. Zinc I have found the most satisfactory material for casements, and if the quarries are well proportioned and not too large, their effect differs very little from that of lead.

In illustrating the general principles to be advocated as applicable, particularly to town buildings, it will be convenient to refer to the dwellings erected by the Society for Improving the Condition of the Labouring Classes. This Society was established in 1844, under the patronage of her Majesty the Queen, with the Prince Consort as its illustrious President. Influenced by the philantrophic principles so powerfully advocated by their noble chairman, Lord Ashley, and stimulated by his example, the committee of this Society undertook, as one most important branch of their labours, "to arrange and execute Plans as Models for the Improvement of the Dwellings of the Labouring Classes, both in the Metropolis and in the Manufacturing and Agricultural Districts." For the past five years they have been steadily engaged in presenting successive models of improved dwellings adapted to the various circumstances of the industrial classes.

With these views, the Society proceeded to build between Gray's-inn-road and the Lower-road, Pentonville, near Bagnigge-wells, their first set of model dwellings on the only eligible site of ground then offered.

1. Nine families occupy each an entire house, with a living-room on the ground floor, having an inclosed recess, or closet, large enough to receive beds for the youths of the family, two bed-rooms on the upper-floor, and a small yard at the back: these houses are let at a rent of six shillings per week.

2. The remaining fourteen families are distributed in seven houses, each family occupying a floor of two rooms, with all requisite conveniences; and as the apartments on the upper floor are approached through an outer door distinct from that belonging to the lower floor, their respective occupants are thus kept entirely separate, and each floor is virtually a distinct dwelling. The rent paid by each family is three shillings and sixpence per week.

A *wash-house*, with drying ground, is provided for the occasional use of the tenants of these houses, at a small charge.

3. The centre building on the east side will accommodate thirty widows or females of an advanced age, each having a room, with the use of a wash-house common to them all. The rent paid for each room is one shilling and sixpence per week. Subsequently it has been thought by the Committee that this rent should have been fixed at two shillings per week.

Where space will admit of it, some modification in the arrangement of houses built after this general model would be desirable. The Society has published a plan in which these alterations are embraced.

Encouraged by the immediate occupation of their first set of buildings, and the approval of the public manifested by liberal contributions to their funds, the Society next proceeded to exhibit a model of an improved lodging-house for working men.

To show the practicability of effecting a great improvement in the existing lodging-houses, the Society began by taking three lodging-houses in one of the worst neighbourhoods in London—viz., Charles-street, Drury-lane. These they completely renovated and converted into one house, which has been fitted up with clean and wholesome beds, and all other appurtenances requisite for the health and comfort of eighty-two working men, who pay at the same rate as is charged for the wretched accommodation afforded in ordinary lodging-houses—viz., fourpence per night, or two shillings per week, and cheerfully conform to the regulations of the establishment. In a financial point of view, this experiment is amply remunerative to the Society.

But, however valuable as an experiment, and calculated as a stimulant to produce highly beneficial results, the house in Charles-street cannot be considered as the model of what a lodging-house ought to be. The Committee therefore purchased a piece of freehold ground in George-street, St. Giles's, surrounded by other lodging-houses, and have built on it a model lodging-house for 104 working men.

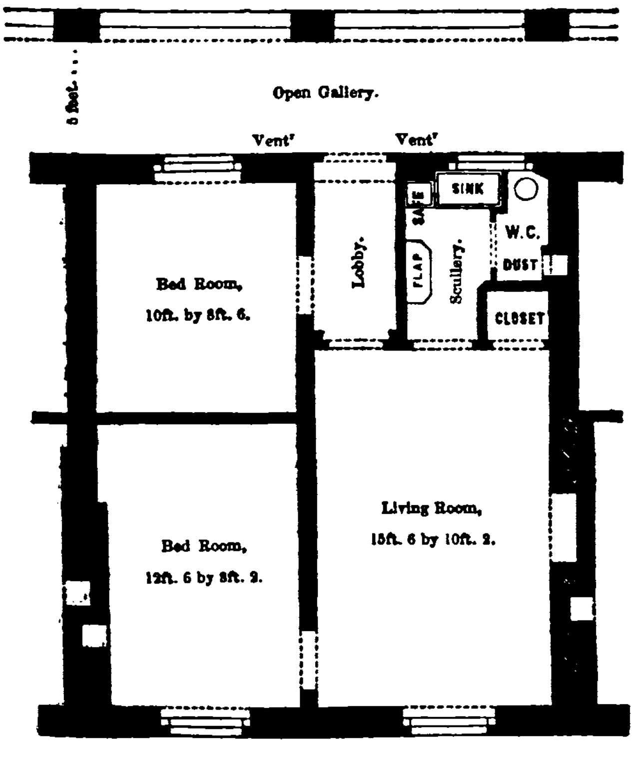
The Plans fully describe the arrangement of the several floors; and the fitting-up of the principal apartments may be thus briefly stated:—The kitchen and wash-house are furnished with every requisite and appropriate convenience; the bath is supplied with hot and cold water; the pantry-hatch provides a secure and separate well-ventilated safe for the food of each inmate. In the pay-office, under care of the superintendent, is a small, well-selected library, for the use of the lodgers. The coffee, or common room, 33 feet long, 22 feet wide, and 10 ft. 9 in. high, is paved with white tiles, laid on brick arches, and on each side are two rows of elm tables, with seats; at the fire-place is a constant supply of hot water, and above it are the rules of the establishment. The staircase, which occupies the centre of the building, is of stone. The dormitories, eight in number, 10 feet high, are subdivided with moveable wood partitions 6 ft. 9 in. high; each compartment, enclosed by its own door, is fitted up with a bed, chair, and clothes-box. In addition to the ventilation secured by means of a thorough draught, a shaft is carried up at the end of every room, the ventilation through it being assisted by the introduction of gas which lights the apartment. A ventilating shaft is also carried up the staircase for the supply of fresh air to the dormitories, with a provision for warming it if required. The washing closets on each floor are fitted up with slate, having japanned iron basins, and water laid on.

The Society has recently fitted up in Hatton-garden a lodging-house for fifty-seven women, which may be referred to as the completest example of the adaptation and arrangement of an old house with all the conveniences desirable in such an establishment.

The question of lodging a large number of families in one lofty pile of building has been the subject of much discussion, and in reference to it the most contradictory opinions were stated before the Health-of-Towns' Commission. Some thought it the best adapted and most economical plan to provide in one house, with a common staircase and internal passages, sufficient rooms for lodging a considerable number of families, giving them the use of a kitchen, wash-house, and other necessary conveniences, in common; others objected that such an arrangement would lead to endless contentions, and be attended with much evil in cases of contagious disease. It must be obvious that in many localities where labourers' dwellings are indispensable, it is impossible to provide them with isol[illegible] altogether independent tenements; and therefore, though modified by local and other circumstances, it will be found the general practice in Great Britain, as well as in the large continental towns, for several families of the working classes to reside in one house.

The important point, then, for consideration, is, in what manner can the advantages of this economical arrangement be retained, without the serious practical evils which have been referred to?

In providing for the accommodation of a large number of families in one pile of building, a leading feature of the plan should be the preservation of the domestic privacy and independence of each distinct family, and the disconnection of their apartments, so as effectually to prevent the communication of contagious diseases. This is accomplished in the model houses built in Streatham-street, Bloomsbury, by dispensing altogether with separate staircases, and other internal communications between the different stories, and by adopting one common open staircase leading into galleries or corridors, open on one side to a spacious quadrangle, and on the other side having the outer doors of the several tenements, the rooms of which are protected from draught by a small entrance lobby. The galleries are supported next the quadrangle by a series of arcades, each embracing two stories in height; and the slate floors of the intermediate galleries rest on iron beams, which also carry the inclosure railing. The tenements being thus rendered separate dwellings, and having fewer than seven windows in each, it is confidently submitted are not liable to the window-tax—which, in a financial point of view, is a consideration of much importance—a saving of at least between seventy and eighty pounds per annum being thus effected on the entire range of buildings.



PLAN OF ONE OF THE TENEMENTS.

The plan at a large scale exhibits one tenement or set of apartments with their appropriate fittings, which comprise all the conveniences requisite for a well-ordered family, and include, in addition to the bed-rooms, a provision for an inclosed turn-up bed in a closet out of the living-room.

The nature of the foundation rendering excavation to a considerable depth indispensable, a basement story has been formed, with a range of well-lighted and ventilated workshops.

The floors and roofs of these buildings are rendered fire-proof by arching with hollow tiles or bricks slightly wedge-shaped. They are 6 inches deep, 4 inches wide on the top part, 9 inches long, ⅞ths to 1 inch thick; the rise of the arches is from ¾-inch to 1 inch per foot on the span, and they are set in Portland cement in the proportion of one part cement to two parts sharp sand, the tiles being well wetted before being used.

The arrangement of the building is such as to render the floor and roof arches a continual series of abutments to each other, excepting at the extremities, where they are tied in with ⅞-inch iron rods, secured to stone or cast-iron springers. The roof is levelled with concrete, and asphalted. The floors of the bed-rooms are boarded on joists 2 inch square, cut out 1 inch on the back of the arch, and secured to two sleepers; the remainder of the floors are in Portland cement, excepting the basement, which is of metallic lava.

The extra cost of rendering this building fire-proof, as well as preventing the communication of sound, and all percolation of water between the several floors, by means of the tile arches, beyond the cost of construction with the ordinary combustible floors and roof, as ascertained by comparative tenders, do not exceed about 12*s*. per cent. on the contract for the entire pile of building, which is 7370*l*.; and, in all probability, when a regular demand arises for roof and floor arch-tiles, they will be supplied at such a price as to allow of their use without any extra cost.

The Metropolitan Association for Improving the Dwellings of the Industrious Classes was incorporated by royal charter in October, 1845, and their first range of dwellings, built in the Old Pancras-road, for the accommodation of 110 families, was opened for reception of the tenants early in 1848. These buildings, from the designs of Mr. Moffet, present an extended and imposing front of about 226 feet, with advancing wings, and are five stories high. The subdivision into distinct double-houses, with a central stone staircase to each, is similar to that of the Birkenhead buildings. They are not fire-proof, but have the advantage of larger-sized apartments, and unobstructed light and air. The internal staircase arrangement involves them equally in the heavy charge of window-tax, which, on the whole pile of buildings, amounts to about 150*l*. per annum. These buildings have been constantly occupied since their completion, and the most gratifying evidence has been given of the change produced in the health and comfort of the tenants, by their improved and salubrious dwellings.

The second undertaking of the Metropolitan Society has been the building in Spitalfields of a lodging-house for 234 single men, with dormitories arranged on a similar plan to those in the George-street, Bloomsbury, lodging-houses, opened in 1847. The living-room accommodation is more extensive and costly, as it comprises a coffee-room 45 feet by 35 feet, a kitchen 46 feet by 21 ft. 9 in., a lecture-room 35 feet by 21 ft. 9 in., and a reading-room 25 feet by 21 ft. 9 in. This building is just completed from the designs of Mr. W. Beck. The charge for each lodger has been fixed at 3*s*. per week, whilst that in George-street, Bloomsbury, is only 2*s*. 4*d*. per week; it remains to be seen whether the extra payment beyond 4*d*. per night, the usual charge for lodging for single men, will be paid for such increased accommodation. It may also be questionable how far the class of men for whom lodgings in such a neighbourhood are chiefly needed, will be really benefited by the luxuries here provided, and which but few men in full employment can have much time for enjoying. It should, however, be observed, that the proximity of this establishment to the spacious range of dwellings for families, building by the same Association, affords the opportunity of appropriating to the use of the occupants of those dwellings, during certain portions of the day, some of the accommodation afforded in this building, and thus turning to good account what might otherwise be surplus accommodation.

The internal plan of these dwellings for families is similar in general disposition to those in the Old Pancras-road, the relative position of the door and fire-places in the living-rooms is better than in the latter buildings, but the position of the entrance under the centre of the staircase, from apparent want of height, is unsatisfactory.

Besides the new buildings to which reference has been made, the spirit of improvement has in several places been manifested by the re-modelling of old buildings, and fitting them up as near as circumstances will admit on an improved and sanitary plan, so as to render them healthy and comfortable abodes. That improvements of this description might be effected to a very great extent, with immense advantage to the working classes, and a handsome remunerative return to those who undertake them with judgment, and who do not shrink from the trouble which they involve, the experience of the Society for Improving the Condition of the Labouring Classes has clearly demonstrated.

In adapting and fitting up old buildings, as well as in erecting new ones, experience has taught the importance of a judicious selection of the locality, which should not be too far removed from the daily occupation of the expected tenants, nor should they be in close contact with the residences of a much higher class in society.

In reference to new buildings for the labouring classes, the most rigid economy of arrangement, consistent with accommodation sufficiently spacious to be convenient and healthy, and the utmost attention to cheapness of construction, consistent with durability and comfort, are essential elements of a really good and suitable plan. The architect should bear in mind that the rents which the working classes usually pay, though exorbitantly high for the wretched accommodation afforded them, will only just yield a fair return for the outlay on buildings constructed for their express use, and fitted up with all the conveniences which it is desirable they should possess. Any expenditure on unnecessary accommodation, which involves an increase of rent beyond that usually paid by the occupants of such a class of dwellings, appears to be at least hazardous, and may jeopardise the whole or a portion of the interest to be fairly expected from the investment.

The remaining branch of my subject, on which I have now to speak more particularly, is that of labourers' dwellings in agricultural or country districts.

The attention of landed proprietors has often been directed to the necessity for the improvement of labourers' cottages, and in not a few instances the entire aspect of a village and neighbourhood has in this respect been completely changed by the well-directed efforts of a single landlord. Illustrations might be drawn from the example set by many noble and wealthy proprietors: in the first instance I will cite a case which shows how, with comparatively limited means, much good may in this way be effected. In the recently published memoir of John Howard, it is recorded that when he first went to reside at Cardington, in Bedfordshire, about 1756, he found it one of the most miserable villages which could have been pointed out on the map of England. Its peasant inhabitants were wretchedly poor, ignorant, vicious, turbulent, dirty. With his characteristic energy and earnestness, Howard set himself, within the sphere of his own competence and influence, to ameliorate their condition both in a worldly and spiritual sense. Beginning with his own estate, he saw that the huts in which his tenantry, like all others of their class, were huddled together, were dirty, ill-built, ill-drained, imperfectly lighted and watered, and altogether so badly conditioned and unhealthy, as to be totally unfit for the residence of human beings. He resolved to begin his work at the true starting point, by first aiming to improve their physical condition—to supply them with the means of comfort; attaching them thus to their own fireside, the great centre of all pure feelings and sound morals—to foster and develope in them a relish for simple domestic enjoyments.

The first step which he took in furtherance of these objects was obviously a wise one, that of rendering the *homes* of the poor dwellings fit for self-respecting men. This must indeed be the starting point of every true social and industrial reformation.

Your attention must now be directed to the very important communication on the dwellings for agricultural labourers made by his grace the Duke of Bedford through the Royal Agricultural Society, in a letter addressed to the Earl of Chichester, President of that Society, for the past year; and I feel assured that it will not be deemed unsuitable for me to quote such high authority on the obligations of landed proprietors.

I have lately had the pleasure of examining a considerable number of the new cottages recently built, with judgment and great care, on the Duke's Bedfordshire property, which already exceed 100; and it is the intention of his grace gradually to continue the re-building of decayed tenements in the same county, until 300 more are erected. The building establishment at Woburn Abbey is on a princely scale, comprising extensive machinery, worked by a steam-engine of twenty-five horse power, and provides employment for 200 workmen.

In Devonshire the duke is carrying out the same spirit of improvement, to the extent of sixty-four cottages.

The example thus nobly set by the Duke of Bedford has been speedily followed by his grace the Duke of Northumberland, and other landed proprietors have also undertaken the same good work.

Plans of cottages built by the Marquis of Breadalbane, are published in the volumes for 1843 and 1845, of the *Transactions* of the Highland and Agricultural Society of Scotland; and plans of the Duke of Bedford's cottages are published in the last July number of the *Journal* of the Royal Agricultural Society.

To facilitate the adoption of plans which combine in their arrangement every point essential to the health, comfort, and moral habits of the labourer and his family, with that due regard to stability and economy of construction which is essential to their general usefulness, the Society for Improving the Condition of the Labouring Classes published, and circulated extensively, a series of designs for cottages, prepared with these special objects in view.

Each dwelling consists of a living-room, the general superficial dimension of which is about 150 feet clear of the chimney projection. A scullery containing not less than about 60 feet or 70 feet superficial, which is of sufficient size for ordinary domestic purposes, without offering the temptation to its use as a living-room for the family; besides a copper, and in some cases a brick oven, provision is made for a fire-place in all the sculleries, by which arrangement the necessity for a fire in the living-room through the summer is avoided. A pantry for food, a closet in the living-room, and a fuel store out of the scullery, are provided in all the cottages.

The sleeping apartments vary somewhat in dimensions; that for the parents in no instance contains less than about 100 feet superficial, whilst the smaller rooms for the children average from 70 feet to 80 feet superficial. The height from the ground floor to the first floor is 8 ft. 9 in. giving nearly 8 feet clear height for the living-room. The bed-rooms are 7 ft. 9 in. where ceiled to the collar pieces, and 4 feet to the top of the wall-plate, which, for the security of the roof, is in no case severed by the dormer windows.

In reference to situation, where it is practicable the front should have somewhat of a southern aspect; the embosoming in trees should be avoided, and particular attention ought to be paid to secure a dry foundation; where this is not otherwise obtainable, artificial means should be adopted by forming a substratum of concrete, about twelve inches thick, or by bedding slate in cement, or laying asphalte through the whole thickness of the wall under the floor level. The vicinity of good water and proper drainage are points of obvious importance. A gravelly soil is always preferable to clay, and a low situation is seldom healthy.

It is desirable that every cottage should stand in its own inclosed garden of not less than about ⅛-th of an acre, and have a separate entrance from the public road. One well may generally be made to answer for two or more cottages, and it is of great importance that it be so placed as not to be liable to contamination either from the drains, cesspools, or liquid manure tank; the latter should, however, invariably be made water-tight, the cost of which will soon be repaid to the tenant by its fertilising products.

As respects the material used in the external walls of cottages, much must depend on local circumstances, and the facility with which the various kinds of natural or artificial substances adapted to the purpose are obtainable.

The various designs published by the Society have, for the reasons previously stated, been wholly arranged for brick, but by increasing the thickness of the external walls they will be equally well adapted for cottages built with other materials. The external walls are described as 9 inches thick, and when built of this substance, in order to secure their dryness, unless the bricks are unusually impervious to moisture, it is strongly recommended that the walls should be hollow; this may be effected by three methods, two of which require that the bricks be made on purpose. The plan No. 1 has been used to some extent; and unless where the bricks are so porous as to cause a transmission of moisture through the heading courses, this plan will be found to answer, rendering the walls dryer and cheaper than when built in the ordinary way. Three courses, with the joints, rise 1 foot, the bricks being 3¼ square; they are of the ordinary length—viz., 9 inches.

The other plan is that of hollow bricks made wedge-shaped, and bonded longitudinally over each other, so that two cavities run parallel through every course of bricks, giving a double security against moisture, as there are no holders to pass through the wall; the rise of these bricks is also three courses to the foot, and they are 12 inches long, which diminishes the number of joints, and gives greater boldness to the work, more resembling stone in effect. These bricks are patented; they may be easily made with any tile machine at a small cost per thousand above that of sound common stocks; whilst from their increased size, which adds but little to their weight, and nothing to the duty, it is found that nine of them will do the same number of cube feet of walling as sixteen ordinary stocks. The saving in mortar is full 25 per cent., and the labour, to accustomed workmen, considerably less than to ordinary brickwork; whilst great facility is afforded by the cavities both for ventilation and warming. It should be added that the bricks for the quoins and jambs may be either solid or perforated perpendicularly.*

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* In addition to the patent bonded hollow-bricks, the application of which to the con-

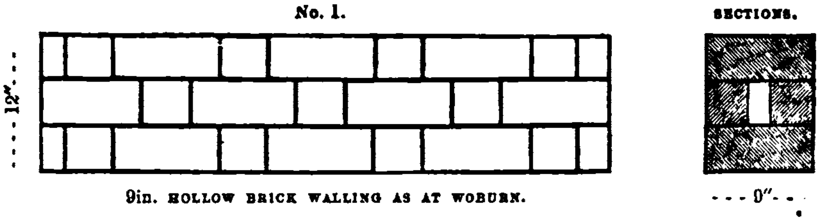
Where it is impracticable to obtain bricks made on either of the plans above described, the walls may be built hollow, 11 inches wide, with common bricks, (see Plan, No. 3); a cavity of 2 inches being left in the centre, and the length of the headers being made up with 2-inch closurs, would bond every course and render them perfectly dry.

Where flint or concrete is used, the walls cannot be less than 12 inches thick with either material; they may be lined with the patent hollow brick, which would bond every course.

The main partitions on the ground-floor should be of brick—hollow bricks, or Messrs. Hertzlet and Co.'s rebated tiles, 12 inches square, where obtainable, may with advantage and economy be used for this purpose; in either case, they should be set in Roman or Portland cement. Where the upper-floor partitions stand perpendicular over those to the ground-floor, brick or tile is decidedly preferable to wood. Stairs may also be made of fire-brick clay, with great advantage. The ground-floor should be raised not less than six inches above the external surface, and where wood floors are used they ought to be ventilated by means of air-bricks built in the external walls. The warmest and most economical floor is probably that formed with hollow bricks. In some parts of the country, lime and sand floors are pretty generally used, and found to last, when well made, upwards of forty years.

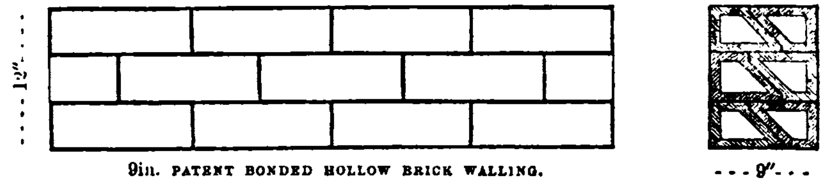
Tiles will generally be found a preferable covering for the roofs to slate, being warmer in the winter and cooler in summer, and requiring much less lead, are decidedly more economical in some localities; however, slate may more effectually exclude the weather.

No. 1.



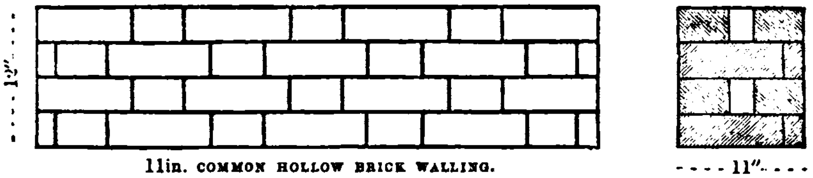
9in. HOLLOW BRICK WALLING AS AT WOBURN.

No. 2.

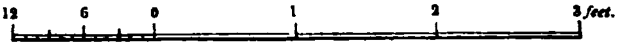


9in. PATENT BONDED HOLLOW BRICK WALLING.

No. 3



11in. COMMON HOLLOW BRICK WALLING.



In closing these remarks on the Dwellings of the Labouring Classes, I cannot but add that it will be to me a source of permanent satisfaction if they should prove of any service to the members of the Institute, or conduce in any way to the removal of obstacles which present so formidable a barrier to the social and religious advancement of a numerous and deserving class of the community.

To contribute to the welfare of our fellow-creatures, with a view to the glory of God, carries with it that durable happiness which the pursuit of wealth, of fame, or of fleeting pleasure cannot afford.

Mr. **Sydney Smirke**, V.P., rose to express his thanks to Mr. Roberts for laying before the meeting his views on this important subject, and also for the clear, intelligible, and accurate manner in which he had done so. This was a subject of great public interest and importance. It was a subject he had long felt an interest in, and he (Mr. Smirke) believed that his attention was first directed to it by becoming acquainted with the fact that an individual, enjoying the luxury of a private carriage, and giving his son the benefits of an university education, derived his income from some low lodging-houses in St. Giles's. This was sufficient to satisfy him of the inordinate extent to which the poor were surcharged for their habitations; of one thing he was quite certain, namely, that the poor paid far more, in proportion, than the rich, for their lodgings and food. This was now pretty well understood to be the case with regard to their lodgings. It must also be admitted to be the case with respect to their food: it was impossible, in all London, from Bond-street to Cheapside, to go into any more extravagant shop than the small chandlers' in the suburbs of London. In such places the worst possible article was sold at the highest possible price. The owners of those establishments had realised that *summum bonum* of political economy—they bought in the cheapest market, and sold in the dearest. He did not think we should have done all we could, or ought to do, for the improvement of the working classes, until we shall have used every possible exertion to secure for them those two great requirements, namely, cheap and healthy lodgings, and cheap and wholesome food. From what Mr. Roberts had detailed that evening, he (Mr. Smirke) thought that the poor were in a fair way to obtain the first-mentioned desideratum, and he hoped that with respect to the second, success need not be regarded as impossible. He (Mr. Smirke) hoped he might be permitted to suggest the establishment, in every parish, of a large store of the principal articles of food consumed by the poor, to be sold only to those who were known to be in needy circumstances; such articles to be really pure and good of their kind, and charged at fair moderate prices. With respect to the more immediate subject of the paper before them, he had but one other remark to make—that all those, who had from circumstances been enabled to know anything of the habits of the working classes in their own homes, must admit, that as tenants, they were rather a destructive class. On this account he thought the interior fittings of all dwellings for the poor should be formed as indestructible as possible; plaster was not fit for the walls of the rooms; the chimney hearths should be of cast-iron, and the ironmongery generally should be of special strength and simplicity.

Captain **Buller**, R.N., observed, that some years ago he made tiles a foot long and six inches thick, and as he used them singly the walls were only six inches thick. He plastered them inside, and they are very dry, except when there is much wind and driving rain. He sometimes used those bricks for flooring, as they are very dry. An objection, however, arose to their use. It was a very dry place where he introduced them, and the ants finding them comfortable residences, crept in, and often annoyed people by eating up their bread and butter. In other respects they answered the purposes anticipated. Two cottages built together cost him about 100*l.*, consisting of two rooms and a kitchen, 13 feet square, all on the ground floor.

Mr. **Godwin** called attention to the oppressive and injurious tendency of the window-tax on such dwellings, and hoped that all present would aid in leading ministers to consider a matter of such moment.

The Rev. Mr. **Eddrup** stated, that having had some experience in visiting the poor, both in town and country, he could assure the meeting that the condition of their dwellings was one of the greatest obstacles the clergy had to contend against, in endeavouring to make their moral condition better and holier. The miserable state in which many of them are compelled to live, constitutes the chief difficulty. The bed-rooms of the poor are often so over-crowded that modesty, reverence, and decorum are almost entirely destroyed. He strongly sympathised therefore in this admirable movement for the benefit of the labouring classes.

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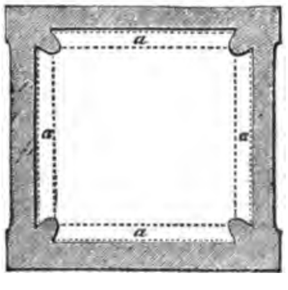
struction of walls has been fully described it may be useful to give a section and description of a hollow brick, designed by Mr. Rawlinson, C.E., whose attention has been much directed to this subject, and who states that it combines many advantages, and may be moulded as easily as any other form. The angle ribs in the inside give strength and surface at that portion of the joint, and admit of tile or slate dowels being inserted on any or all of the sides, to close the joint; by this means a continuous flue, perfectly tight, may be formed. Two of the external faces are even and plain, two are partially recessed; these latter are supposed to be the beds or side-joints, as the case may be, the slight sinking of about 1-16th of an inch being to relieve the hollow side and thin portion of the brick from undue weight or bearing in the work,—to bring this on the solid edges, and also to act as a slight lock, or dowel, with the cement or mortar. The joint dowels will only be required where one surface or more is exposed, or where any particular course requires to be made into a continuous flue, for ventilation or any other purpose. For partitions, or for lining external walls, where plaster is to be used, the dowel will not be required.



MEDIÆVAL BRICK BUILDINGS OF GERMANY.

On the Mediæval Brick Buildings in the North-East of Germany, and on the Coast of the Baltic. By Charles Fowler, Jun., Esq.—(Paper read at the Royal Institute of British Architects, February 18th.)

In requesting your attention to some of the examples of the Mediæval Brick Buildings which we find in the north-east of Germany, and the adjoining coasts of the Baltic, I can hardly preface my remarks better than by laying before you the observations of one of the best authorities on the history of our art—I mean Dr. Franz Kugler, who, in reference to the buildings in question, says in his Handbook: "The *Germanic style* is developed in a peculiar manner on the coasts of the Baltic, and in some of the adjoining districts of Germany, viz., Holstein, Mecklenburg, Pomerania, the Old and New Mark Brandenburg, Prussia, Curland, Liefland, and also in the Scandinavian countries. These countries were connected and very much influenced by the confederation of the Hanse towns, and it is probably to this influence that we may ascribe much of the similarity of style visible in the buildings of the districts referred to, though, in some instances, other circumstances may have concurred to produce many of the peculiarities which we find. The Germanic style of the Baltic countries is distinguished from that development of it which attained the greatest perfection in *Western Germany*, by its greater simplicity and massiveness; though it is by no means devoid of artistic feeling, particularly in the bold proportions of the interiors, and externally in a peculiar style of ornament. It has been thought by some that the peculiarities of this style are to be accounted for entirely by the materials principally used in the construction: granite and brick, the former difficult to handle, the latter only obtainable in blocks of very small dimensions; but without wishing altogether to deny this influence of material, we shall more probably find the origin of this simple and peculiar, but effective style of architecture, in the rude but energetic character of the people by whom the. monuments in question were erected. The influence of material is more decidedly visible in the decorative parts.

This peculiar style appears to extend over a considerable tract of country, but its most complete development is found in the Old Mark Brandenburg, and the principal Hanse towns, Hamburg and Lubeck. The earliest buildings in which brick appears as the prevailing material date their commencement in the latter part of the 12th century. But it is not till the end of the 13th century that we find any examples of importance, and the style was fully developed during the 14th and down to the middle of the 15th centuries. The earliest examples of this style are, as might be expected, ecclesiastical structures, and the prevailing character of these is, as we have already heard, simplicity and massiveness. The form of the plan is at first the cross, the choir having a polygonal apse with the aisle continued round it, and sometimes also small chapels spreading beyond; the floor of the choir is considerably raised, and a crypt formed under it; but the transepts were sometimes omitted, retaining the same arrangement of the choir. The best examples of this early style are to be found in the churches of Rive, Odensee, Ringstädt, Roskilde-on-Zeeland, and the adjoining islands.

In these examples we find the semi-arch, small windows, and many other features of the Romanesque buildings, with which they are nearly coeval, but probably a little later. But by far the greater number of existing examples belong to a later period, as already mentioned, and these exhibit more peculiar features. The plan now presents nave and aisles only, the choir still terminates polygonally, and the aisle is sometimes continued round it; but frequently the aisles are also closed at the east end by a small apsis, and in this case the choir is continued eastward beyond the aisles; the choir is always marked by being raised a few steps. The space between the wide projecting buttresses is sometimes occupied by small chapels, both round the east end and at the sides of the aisles. The towers are, I think, invariably placed at the west end only; and there is most commonly only one, which is imbedded in the body of the church, so that the west façade is unbroken, and the tower only shows itself above the roof; in this arrangement buttresses would not have added to the apparent stability. The aisles are of equal height with the nave, or at least the vaulting springs from the same line. The roof is generally in one span over nave and aisles, rendering it a very important feature externally from its necessarily great height; the usual covering is copper. The windows are of narrow proportions, and without transoms; the tracery, where not of stone, is of a very simple and even rude character, though there are exceptions. The doorways are generally small, but deeply recessed, with rich mouldings; porches are not common, but I am able to exhibit one example from the Dom Lübeck. The form of the arches is generally about the equilateral, the pier arches more depressed. The piers are mostly of simple form, as circular or octagon, with four attached vaulting shafts; but there are examples of a more elaborate composition. The vaulting is generally the simplest form of cross vault, without any wall or ridge ribs; in each compartment, between the transverse ribs, the vault rises domically, so that there can hardly be said to be any ridge at all, as the vertical section through the centre of the vaulting would present somewhat the appearance of a series of irregular shaped domes; and, probably with a view to lighten the construction, the centre is left as an open eye, round which the moulding of the ribs is continued. In some instances the brick-work of the interior has been simply pointed, and left without any plastering or colouring except in the vaulting; this treatment, though it produces rather a gloomy effect, is perhaps preferable to the indiscriminate whitewash.

Of the exterior the most striking feature are the towers, though usually single, and placed at the centre of the west front. They are of large dimensions, both on plan and in elevation, but of exceedingly simple outline; without buttresses, and with scarcely any ornament but the bands of sunk tracery which divide the different stories. The openings are small, too much so apparently to let out the sound of the bells; some of the smaller of these are therefore occasionally found on the outside, in a kind of balcony. The towers are most commonly square, up to the commencement of the spire, which is octagonal, and constructed of wood covered with copper or lead; the transition is made by gables on the four sides of the tower, but there are some examples where the upper part of the tower itself is octagonal.

The Spire is generally more than half the whole height, without any attempt at ornament, and terminates in a simple vane. The form is very taper, and is elegant from its simplicity; essentially different from the heavy spires of the Romanesque churches on the Rhine, which in construction they resemble.

As the Roof is generally continuous over both the nave and the choir, the division is marked externally by a kind of lantern with a small spire, placed on the ridge of the roof; and this is called a Roofrider, a term very expressive of its position, though the saddle is none of the easiest.

Most of the towns of the Mark offer several examples; I shall therefore only take some of the most important with which I am acquainted. The Church of St. Mary's, Lübeck (1250—1360) is one of the most striking; its great size, the two lofty towers, and the circumstance of its having the exceptional arrangement of a clerestory, all contribute to render it so. The extreme length inside is 340 feet, and the height of the nave 128 feet. The Briefkapelle, which is a rather later addition on the south side, is one of the most elaborate and interesting specimens of this style with which I am acquainted. The vaulting is supported by two octagon polished granite shafts, 14 inches diameter and 38 feet high. I will here just mention the heights of the different church towers at Lübeck, which are certainly very much beyond our usual standard.

Height of Tower of	St. Peter's	284	English feet.
" "	St. Ægidus	312	"
" "	St. James's	316	"
" "	The Dom	391	"
" "	St. Mary's	404	"

The Dom (1174—1341) is the oldest church in the town; it has likewise two towers. Of the early part we have not much left, it is at the west end: the north porch, judging from the mouldings, cannot, however, be much later than 1200. The Church of St. Katharine (about 1320) has a remarkable arrangement of the choir, which forms a kind of gallery, raised on columns and vaulting, and was so disposed for the convenience of the nuns of the convent to which this church was attached. There is one other of the ecclesiastical buildings of this city which deserves particular notice; the so-called *Heiligen Geist Spital* (Hospital of the Holy Ghost), founded 1234, now a church, but originally a religious establishment for the reception of the sick and wounded that returned from the Holy Land, and for sick travellers generally. The west front is very peculiar; this part of the building formed originally the chapel of the Hospital, it is now only the vestibule to the church. At Hamburgh the churches have suffered more from modern alteration and destruction: the great fire in 1842 destroyed two of them, St. Peter's and St. Nicolas. Only two of the original churches now remain, and they have been much altered.

The small town of Tangermünde, on the Elbe, contains some very good examples—the Conventual Church and St. Stephen's; in the latter much of the moulded work is in stone. A short distance from this town there is a very interesting example of the early period of the brick style, in the church at Jerichow (before 1200), in which the semicircular arch is used throughout; there is also a crypt; the cloisters, which still remain, show this to have been a conventual church. Not far from Tangermünde, in another direction, is situated the ancient capital of the Mark Brandenburg—Stenthal, where there are several fine churches of the brick style (the Dom, St. Mary's, St. James's, and St. Peter's), all on a very large scale. At Brandenburg, the Dom affords another example of the earlier period, at least in part. The Church of St. Katharine (1401), partakes externally rather of the civil than ecclesiastical character; the façade has a stepped gable. I will only mention further the Church of St. Nicolas, at Stralsund (begun 1311), and that of St. Mary, at Stargard, in Pomerania, both of which are stated to be particularly fine examples of the style.

We will now turn to the *Civil Architecture* of the brick style, examples of which do not occur till about the latter part of the fourteenth century, and they are generally of a much more elaborate character, with greater subdivision of parts, and more profuse decoration. Among these buildings the town halls or senate houses form an important class, but they will hardly admit of any general description; further, the gate towers and other fortifications are very worthy of notice; and lastly the private houses, though these do not offer any very great variety. We will therefore proceed at once to examine some of the examples.

The senate house at Lübeck is perhaps the most important of its class, as that town was at the head of the Hanse Confederation, and the delegates from the different cities met in the senate house there, which is therefore much larger than would have been necessary for the purposes of the town council alone. The erection of this building spreads over a considerable period, down as late as the beginning of the sixteenth century, but the most interesting portion is that first erected. It consists of an open arcade, on granite piers, on the ground floor, probably for the use of the market, over which were the halls, &c., lighted by large windows. The roof is masked by a row of turrets, connected by a kind of arcade, which gives a peculiar character to the building.

The town hall at Tangermünde is an example of a different class; the most remarkable feature is the gable end, richly decorated with octagon buttresses, having stories of canopied niches,—the gable is stepped between these buttresses. Altogether it strongly resembles the façade of the Church of St. Katharine, at Brandenburg, and dates probably from the same period, the beginning of the fifteenth century.

The Hall of Justice (as it is called) at Brandenburg presents a somewhat different arrangement; it is by no means so fine an example as that last mentioned. The arrangement of the centre of the front is very peculiar; there is elaborate tracery at the heads of the door and windows, and this, if coeval with the rest of the building, would assign a late date for its erection.

Having before alluded to Stralsund, I will here mention that the town hall there (built 1316) is spoken of as having seven towers, most probably somewhat in the manner of that at Lübeck. There are numerous other examples, which appear mostly to date from the fourteenth and beginning of the fifteenth centuries.

Many towns of the district we are considering appear to have been fortified by a continuous wall, generally of brick-work with turrets at intervals, and with large gate-towers, both single and double. Very fine examples of the latter are found at Lübeck, but the enceinte appears in this case to have been an earth-work, though not that now existing. These towers were, without doubt, originally crowned with battlements, as is still the case in some other examples; but even as they now are they form imposing entrances to the town. The date of these buildings would appear to fall in the middle of the fifteenth century. At Tangermünde the wall is of brick, and remains almost perfect, and there are also some fine gate-towers. At Stenthal we find two good examples of this class of building, at Brandenburg several, and many others.

But I must pass on to another class of examples—the private buildings, of which I find the following description in an old chronicle of the town of Lübeck:—"On one or both sides of the lofty door there is a sitting-room, and at the back a small bed-room, over the former the business room; it was some time before any other window was introduced, besides that common to the sitting and business rooms; the hall for the goods and the several stories in the roof had only wooden shutters." This description is of the houses of the fourteenth century, but with very slight alterations it would embrace the greater part of the town at this day.

In 1209 the town of Lübeck was nearly destroyed by fire, and previous to this period the private buildings were probably entirely constructed of wood, as after the fire the senate passed a *Building Act*, which ordered that at least both the gable ends of private houses should be of brick. The principal feature of the private buildings are the stepped gables, which are sometimes of great height, and of which every possible variety is met with. They are decorated with long strips of panels, arch-headed, and divided into stories of niches and openings; these panels are never continued down over the lower part of the house, where the openings have frequently quite a different arrangement. The steps of the gables are very bold, giving a peculiar picturesque character not met with in similar buildings elsewhere. Most of the openings of windows and doors have the segmental arch, being more manageable than the pointed form which is given to those of the niches or panels.

The treatment of the *ornamental* parts in this style is peculiar and well adapted to the material in which they are executed. There is one feature in particular which deserves attention, I mean the introduction of a white plastered ground to relieve the forms of tracery, &c. put over it. This relief by *colour* is rendered necessary by the *dark* hue of the material, owing to which the *shadow* of small projections would not give sufficient relief.

In the early examples of the brick style, the more elaborate parts, including the tracery of the windows and other moulded work, were executed in stone. Horizontal bands of stone were also occasionally introduced, and they have a good effect in tying together the different parts of the composition, besides their value in a constructive point of view. But in the later examples from the end of the fourteenth century, stone is entirely dispensed with, and we find even such parts as crockets and finials executed in *brick*. The use of dark brown or black glazed bricks was also common during the later period. The character of the mouldings varies, of course, somewhat in the different periods, being simpler in the earlier, and more elaborately subdivided in the later; delicacy of profile can hardly be expected from the nature of the material. Moulded bricks were also used to make up general forms, such as circular piers, the inner side of circular turrets, &c.

There are a few points in the construction of the buildings we have been examining which ought not to be passed over. There is usually a granite plinth carried all round the churches, and the towers are faced with the same several feet up. The absence of buttresses to the towers rendered it necessary to increase the thickness of the walls, which we find is very considerable, notwithstanding which they mostly incline from the upright; and it is remarkable that this occurs most frequently towards the south-west. While speaking of the mortar joints, I should mention that they are invariably very wide (from ¼-inch to ¾-inch or even more); the mortar itself is extremely hard, and the lime used was, for the district we are considering, principally supplied from Segeberg in Holstein.

The construction of *vaulting*, I think, claims particular attention; in the first place, a light material was prepared in bricks, moulded of a wedge form. The ribs seem to have been first constructed, independently, as a skeleton, and between them the spandrils were filled in with the light bricks, apparently without the use of centring, as each spandril is considerably arched up to enable it to support its own or any superincumbent weight; thus the vaulting rests entirely on the ribs, which are not tailed into it. It is a single brick in thickness, about six inches, and is backed up only a very short distance above the springing, so that the form is very distinctly seen on the upper surface, where it presents a very remarkable appearance. The bond used throughout is the Flemish, or, as it is there called, the cross-bond; the arches are always built in half-brick rings.

The bricks used in the buildings I have brought under your notice are of a larger size than those now commonly used in the district; they are remarkably hard and sound, and are rather heavy; though externally of a brown red colour, the inside is grey, like our stocks: this is not the case with those now made. The light vaulting bricks were made with a mixture of chopped straw, so that when burnt they were porous, but of sufficient strength for their purpose. I have discovered no examples of gauged work. The first-class bricks, as a material, are superior to those used in this country: the colour uniformly red, except where a vitreous action had been produced in the burning. There did not appear to have been a rubbing down of the face of the material when used for mullions or tracery—the ordinary examples presented too rude a surface to suppose such an operation.

Remarks made at the Meeting after the reading of the foregoing Paper.

Mr. **Smirke** said that he had recently been much interested by a cursory inspection of some examples of old brick-work in Germany. At Hanover and Hamburgh there are churches constructed of brick, with windows having deeply-moulded jambs, and slender mullions of considerable height, wholly of that material. He thought that these instances might be adduced in corroboration of a remark he had made here on a former occasion, that we are in England scarcely aware of the great capabilities of terra-cotta. The application of burnt clay to the purposes of ornamental architecture seems to have been carried farthest in flat alluvial countries, as on the eastern side of England and in western Germany, where, of course, good building stone does not occur, and where the expense and difficulty of transit in former times encouraged the use of artificial materials. In Norfolk and Suffolk, and the adjacent counties, many examples remain of delicate ornamental brick-work. In parts of Germany this fabric is at the present day far better understood than with us. The Bauschule at Berlin is a most remarkable specimen of Schinkel's genius: it is a building of very great extent, and of most elaborate detail, entirely executed in brick-work, unrelieved by any portion of stone. Its dark red colour gives to the building a somewhat heavy general effect, very similar to the red sandstone so much used in some parts of England, but on a close inspection one is surprised at the fineness and delicacy of the details. Throughout western Germany bricks are worked with a fantastic ingenuity rarely visible with us: by the use of various coloured bricks intermixed, an ornamental character is given to the commonest buildings—somewhat whimsical perhaps to our plain English eyes, but yet well deserving observation,

Mr. **Fowler**, sen., had been struck when abroad with the curious specimens of brick-work which he met with, particularly the Old Rathhaus, Hanover. Schinkel's remarkable building at Berlin, whatever might be its merits architecturally, was a striking example of what might be done in brick-work or terra-cotta. The whole of that immense structure was of that material, and it was certainly executed in a very extraordinary manner. It was by no means striking in its outline. He would not have ventured to say that in Berlin, where the worth of Schinkel's works must not be doubted, but he would assert here, that as a piece of architecture it possessed no great merit. It did far greater credit to the person who executed the work; for the able manner in which the details were carried out was surprising, and served to show, beyond what he would have conceived possible, the capability of brick-work as a material. These examples, in stricter phrase, related to terra-cotta rather than to vulgar brick.

Mr. **Bellamy** (the Chairman), remarked that Mr. Sharpe, of Lancaster, had introduced terra-cotta to a great extent in the construction of churches, and with considerable effect. There was, however, at the present time, rather an affectation in the application of brick-work, which it was not desirable to encourage. He had seen instances in which the cost of ornamental construction in brick had exceeded that of stone; whilst, notwithstanding the beautiful effect sometimes produced by a judicious combination of the two materials, it must be admitted to fall short of that obtainable in stone. The practical objection to the combination of rubbed and gauged bricks with the ordinary building brick, by which bond is interrupted and not recovered for several courses, should not be lost sight of in adopting that material.

Mr. **Donaldson** considered that the absence of buttresses, alluded to by the lecturer, on the external faces of these brick edifices materially detracted from their effect. The massive buildings rising up with the landscape, possessed great nobleness in point of mass, but at the same time they exhibited great want of taste. High as their spires rose, and imposing as were their dimensions, they were remarkable for a want of *chiaroscuro* and contrast, which marred their appearance as works of art. The influence of Flemish taste in our brick-work was perceptible in many examples of past times, which might be accounted for by the fact, that the Flemish builders were brought over to execute brick constructions similar to their own. But in this country brick-work, as applied to Gothic detail, had never been carried to the same extent as in the low countries. Our travellers abroad had not so much noticed, as they deserved, the edifices to which attention had been drawn by Mr. Fowler, for the surface of many had been coloured over with a light tint, and they appeared to persons passing through those towns as though they were really of stone, instead of being simply of brick construction.

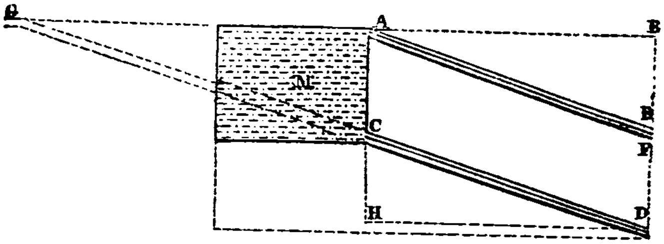
A vote of thanks was then passed unanimously to Mr. Fowler, for his interesting communication.

Ploughing by Steam.—A trial in this way was made at Grimsthorpe, on the 7th ult, by Lord Willoughby de Eresby. It will be sufficient at present to say that the machinery employed consisted of a small locomotive engine, with a capstan attached, moving on a portable railway. An ordinary plough, followed closely by a subsoil plough, was drawn by a chain from the capstan, working with perfect precision, and at a greater depth and speed than usual. Several gentlemen and farmers who were present, expressed a favourable opinion of the experiment. Should the plan be found advantageous, it will be published in full for the benefit of the public.

MOTION OF WATER IN PIPES.

On the Motion of Water in Conduit Pipes; on Friction and Pressure in Pipes; and on Jets d'Eau. By M. D'Aubuisson de Voisins, Ingénieur en chef Directeur au Corps Royal des Mines, &c. &c. —(Translated by T. Howard, for the *Civil Engineer and Architect's Journal.*)

[The Work, of which the present translation forms a part, must be considered as the most important and complete modern treatise on Hydraulic Engineering. In it the author has, with admirable clearness and precision, treated the entire question of the Motion of Fluids; and this in such a way as to render it equally inviting to the practical and the scientific man. The object of the translator is to supply a want which English engineers must long have felt—that of an intelligible explanation of the *Motion of Water in Pipes;* and in carrying out this object, he has considered it due to M. d'Aubuisson and the public, to give the exact meaning of the author as literally as possible. On the same principle, the original equations are given, as well as the same reduced for English feet; for though these reductions have been carefully made, more confidence will be felt in important calculations, where both can be referred to.—Unless otherwise expressed, the whole of the dimensions in the examples are understood to be in English feet, and the time in seconds.]



Similarity of the Motion in Pipes and in Canals.

1. In a long, inclined pipe, as in a canal, water moves by virtue of its gravity or weight, or rather that part of its weight called into action by the slope of the pipe: the accelerating force in both cases is gp.[*] So that, if to the upper part of a reservoir M, we adapt at AB, either a canal or a long pipe,—granting that no obstacle is opposed to the action of this force, the fluid will issue at the point B, with a velocity due to the height EB.

At the commencement of an open canal there is no exercise of pressure on the entering fluid; while there usually is a pressure at the head of pipes. For example, if we bring the pipe AB down to CD, we shall have at C a force of pressure, in consequence of which the water will enter into the pipe with a velocity due to the height AC. According to the first principles of accelerated motion, this velocity should be added to that which the fluid acquires from the effect of the slope from C to D; so that, every obstacle being removed, it will issue with a velocity due to AC +FD, or to ED, the height which represents the force, in virtue of which the flow tends to take place.

In every other respect, this case may again be compared to that of a canal: if we prolong CD up to G, level with the surface of the reservoir, and make a canal from G to D, the water will still tend to run out with a velocity due to ED. Thus, in both cases, in pipes as well as in canals, the accelerating force and the effects which it tends to produce, are the same.

Under the influence of such a force, the motion in pipes should be continually accelerated; and yet, at a very short distance from their origin, it is perceptibly uniform. There must then be, beyond that distance, an opposing force which continually destroys the effect of the former. This opposing force can only be the resistance of the sides of the pipe; a resistance which, as in a canal, arises from the adherence of the fluid particles to these sides and amongst each other.

Thus in pipes we have the same accelerating and retarding forces as in canals; the motion therein is of the same nature: and we may say that pipes differ but in one point from canals—that of having the upper part of the channel closed.

Meanwhile, this difference in the form of the channel gives rise to peculiar circumstances in the movement, which demand special consideration: they will form the subject of this chapter.

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[*] g being velocity acquired from force of gravity in 1 second = 32·19 feet, lat. of London. p being rate of slope, or fall + length.

ART. 1.—OF SIMPLE CONDUITS.

In hydraulics, and particularly in connection with water-works, the name of *conduit* is given to a long series of pipes, joined exactly one to another. The conduit is called *simple* (in opposition to a *system of conduits*) when it consists of only a single line of pipes, conducting to its extreme end all the water it receives at its origin.

1. STRAIGHT CONDUITS OF UNIFORM DIAMETER.

Manner of expressing the Resistance.

2. For greater simplicity, let us unite in one the two forces which tend to produce the velocity of flow—the pressure AC at the head of the conduit, and that of FD which arises from the slope: for this purpose, let us imagine that the given conduit CD is placed horizontally at HI, at the bottom of a reservoir, of which the depth AH = AC + FD = ED. Nothing will be changed in the data of the problem: we shall have the same force and the same resistance, the latter being independent of the position of the conduit.

The force of pressure by reason of which the water tends to run out, or more immediately, the vertical height ED, which is the difference of level between the orifice of discharge and the surface of the fluid in the reservoir, is called the head (*charge de la conduite*). We shall designate it by H.

If the conduit offered no resistance to the motion, setting aside the effect of contraction at the entry, the water would run out with a velocity due to this total height, as we have just seen. But it is not so: the resistance of the sides opposing an obstacle, diminishes this velocity; it consequently absorbs a portion of the motive head H. The flow takes place only by virtue of the remaining portion; which portion is simply the height due to the velocity of discharge, or indeed to the velocity at any point of the conduit, since the motion therein is uniform, and the section everywhere the same.

Let v be this velocity, $\frac{v^2}{2g}$ will be the height due to the velocity or the effective portion of the head; $H - \frac{v^2}{2g}$ will then be the portion absorbed by the resistance.

3. We have thus expressed, by the height H, the effort or the force of pressure which drives the water in the conduit; by the height $\frac{v^2}{2g}$, the force which produces the discharge; and by another lineal quantity $H - \frac{v^2}{2g}$, the resistance or negative force: although it is a principle in mechanics that forces of pressure, or efforts equivalent to weights, ought also to be expressed by weights. I will explain myself on this subject.

We have, in a former chapter, seen that the absolute pressure on a fluid horizontal plane, or portion of that plane, designated by s, was $psH^{\text{lbs.}}$, p being the specific gravity of the pressing liquid. Since, according to the laws of hydrostatics, the pressure is equal on every part of this plane, it will be sufficient, and at the same time convenient, to consider but one part only; this will be an infinitely small one, which we may suppose always of the same area; then s being constant, the pressure will vary only with the specific gravity or the nature of the liquid, and the *height* of its column: it is in this sense that we say that the height of the column of mercury in the barometer expresses the pressure of the atmosphere. If the pressing liquid remain the same (as will be always the case with water in this chapter), we may also pass over its weight p, which is constant; and the pressure will be expressed simply by H, and will be exclusively proportional to it.

If we were rigorously to adhere to the principle, we should regard H as the weight of the fluid filament which presses and drives on in the conduit the molecule which is immediately beneath it; and we should represent it by a line, as in elementary statics we represent by lines, forces which are also weights.

Amount of the Resistance—Fundamental Equation.

4. Since the resistance arises from the effect of the sides, it will be proportional to their superficies—that is to say, to the length of the conduit, and to the circumference of its section, which is here the wet perimeter; for we are supposing that the flow is made in a full pipe, otherwise we should have the case of a simple canal. In other words, the more the section is enlarged, the more also will the resistance of the sides be distributed among a greater number of molecules; consequently, it will less affect each of them and the total mass; it will be in inverse ratio to their number, and consequently to the magnitude of the section. In short, here, as in canals, it will be proportional to the square of the velocity plus a fraction of the simple velocity.

Then, if L be the length of the conduit, S its section, C the wet contour or perimeter, a and b two constant coefficients, the expression of the resistance will be

$$a\,\frac{CL}{S}\,(v^2 + bv).$$

and we shall have

$$H - \frac{v^2}{2g} = a\,\frac{CL}{S}\,(v^2 + bv) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (I.)$$

5. It remains to determine the coefficients a and b. M. Prony, who was the first to undertake this task in an adequate manner, makes use, for the purpose, of fifty-one experiments made by our most able hydraulicians, and which Du Buat had before employed in the establishment of his formulæ. He has deduced therefrom,

$$a = {\cdot}0003485; \qquad b = {\cdot}0498;$$

or, in the value of English feet, $a = {\cdot}0001062$; $b = {\cdot}16339$.

Of these fifty-one experiments, eighteen had been made by Du Buat himself, upon a tin pipe, of 1·063 inches diameter and 65 6 feet long; twenty-six had been made by Bossut, on tubes also of tin, 1·06 inches, 1·42 inches, and 2·13 inches diameter, and whose lengths varied from 31·95 feet to 192 feet; lastly, seven had been made on the large conduits in the park at Versailles, one was 5·3 inches diameter and 7478 feet long, and another 19·3 inches diameter and 3834 feet long.

Twelve years afterwards, Eytelwein treated anew the question of the motion of running waters; he has thought it right to take into consideration the contraction of the vein at the entrance of the conduit, and m being the coefficient for this contraction, he determined (the measures being in mètres),

$$H - \frac{v^2}{2g \times m^2} = {\cdot}0002803\,\frac{CL}{S}\,(v^2 + {\cdot}084\,v)$$

Or in English feet,

$$H - \frac{v^2}{2g \times m^2} = {\cdot}0000854\,\frac{CL}{S}\,(v^2 + {\cdot}2756\,v) \quad \ldots\ldots (II.)$$

But m, whose effect, besides being imperceptible in large conduits, is included in the value of a, given by the experiments. Consequently, and paying regard only to the most exact observations, and especially to those of Couplet, I shall adopt the equation,

$$\left.\begin{array}{ll} \text{[In mètres]} & H - \frac{v^2}{2g} = {\cdot}0003425\,\frac{CL}{S}\,(v^2 + {\cdot}055\,v) \\ \text{[In Eng. feet]} & H - \frac{v^2}{2g} = {\cdot}0001044\,\frac{CL}{S}\,(v^2 + {\cdot}18045\,v) \end{array}\right\} \ldots (III.)$$

For *canals*, the equation is,

$$\left.\begin{array}{ll} \text{[In mètres]} & H - \frac{v^2}{2g} = {\cdot}0003655\,\frac{CL}{S}\,(v^2 + {\cdot}066\,v) \\ \text{[In Eng. feet]} & H - \frac{v^2}{2g} = {\cdot}0001114\,\frac{CL}{S}\,(v^2 + {\cdot}21654\,v) \end{array}\right\} \ldots\ldots (IV.)$$

These two equations are similar and very nearly the same, as should be the case. The slight differences in the numerical coefficients probably arise from errors in the observations. If this be so, as the observations are capable of being made with much greater exactness upon conduits than upon canals or rivers, it may be presumed that the coefficients of the equations for conduits are the more correct.

6. The section of pipes being a circle, if D represent the diameter, we shall have $S = \pi' D^2$, and $C = \pi D$; and by putting for π, π', and g, their numerical values,* the fundamental equation for the motion of water in conduit pipes will become,

$$\left.\begin{array}{ll} \text{[In mètres]} & H - {\cdot}051\,v^2 = {\cdot}00137\,\frac{L}{D}\,(v^2 + {\cdot}055\,v) \\ \text{[In feet]} & H - .0155\,v^2 = {\cdot}0004176\,\frac{L}{D}\,(v^2 + {\cdot}18045\,v) \end{array}\right\} \ldots\ldots (V.)$$

The velocity is very rarely among the quantities given or required in the problems to be resolved; the discharge is the

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* $\pi = 3{\cdot}1416$; $\pi' = {\cdot}7854$.

$\frac{1}{2g} = {\cdot}051$ (In mètres). $\frac{1}{2g} = {\cdot}0155$ (In English feet).

quantity more frequently sought. Let Q be the volume discharged in a second: we have

$$Q = \pi' D^2 v; \qquad \text{or } v = 1{\cdot}273 \frac{Q}{D^2} \text{ .... (VI.)}$$

This value of v, put in the equation above, transforms it to

$$\left.\begin{array}{ll}\text{[In mètr.]} & H - {\cdot}08264\frac{Q^2}{D^4} = {\cdot}002221\frac{L}{D^5}(Q^2 + {\cdot}0432QD^2) \\ \text{[In feet]} & H - {\cdot}02519\frac{Q^2}{D^4} = {\cdot}000677\frac{L}{D^5}(Q^2 + {\cdot}14173QD^2)\end{array}\right\}\text{... (VII.)}$$

Such is the formula which we shall have to employ for the solution of questions relative to the motion of water in conduit pipes; attending always, in its practical application, to the observations which will hereafter follow. Of the four quantities Q, D, H, and L, three being given, the fourth may be found by this formula.

7. When the velocity is great, so as to exceed 2 feet per second, the resistance is sensibly proportional to the square of the velocity; the term in which it is but the first power disappears, and we have, according to the experiments of Couplet,

$$\left.\begin{array}{ll}\text{[In mètres]} & H - {\cdot}051\, v^2 = {\cdot}001435\frac{Lv^2}{D} \\ \text{[In feet]} & H - {\cdot}0155\, v^2 = {\cdot}0004373\frac{Lv^2}{D}\end{array}\right\}\text{...(VIII.)}$$

Or, in terms of Q,

$$\left.\begin{array}{ll}\text{[In mètres]} & H - {\cdot}08264\frac{Q^2}{D^4} = {\cdot}002326\frac{LQ^2}{D^5} \\ \text{[In feet]} & H - {\cdot}02519\frac{Q^2}{D^4} = {\cdot}000709\frac{LQ^2}{D^5}\end{array}\right\}\text{... (IX.)}$$

It will be borne in mind that the second member of the above equations is the value of the resistance arising from the sides of the conduit.

8. Disengaging the value of Q from the general equation, it becomes

$$\left.\begin{array}{ll}\text{[In mètr.]} & Q = -\frac{{\cdot}0216\, LD^3}{L+37{\cdot}2\,D} + \sqrt{\frac{450{\cdot}2\, HD^5}{L+37{\cdot}2\,D} + \left(\frac{{\cdot}0216\, LD^2}{L+37{\cdot}2\,D}\right)^2} \\ \text{[In feet]} & Q = -\frac{{\cdot}0709\, LD^3}{L+37{\cdot}2\,D} + \sqrt{\frac{1477{\cdot}06HD^5}{L+37{\cdot}2\,D} + \left(\frac{{\cdot}2325\, LD^2}{L+37{\cdot}2\,D}\right)^2}\end{array}\right\}\text{(X.)}$$

In long conduits, where 37 D is very little compared with L, we may neglect it; and again neglecting the second term under the root, we shall have for ordinary cases of practice,

$$\left.\begin{array}{ll}\text{[In mètres]} & Q = 21{\cdot}22\sqrt{\frac{HD^5}{L}} - {\cdot}0216\, D^2 \\ \text{[In feet]} & Q = 38{\cdot}4365\sqrt{\frac{HD^5}{L}} - {\cdot}0709\, D^2\end{array}\right\}\text{...(XI.)}$$

9. In great velocities, it is

$$\left.\begin{array}{ll}\text{[In mèt.]} & Q = 20{\cdot}73\sqrt{\frac{HD^5}{L+35{\cdot}5\,D}};\ \text{or, } Q = 20{\cdot}3\sqrt{\frac{HD^5}{L}} \\ \text{[In feet]} & Q = 37{\cdot}034\sqrt{\frac{HD^5}{L+35{\cdot}5\,D}};\ \text{or, } Q = 36{\cdot}77\sqrt{\frac{HD^5}{L}}\end{array}\right\}\text{.(XII.)}$$

If the velocity is required, we obtain its value by dividing the quantity Q by the section $\pi' D^2$.

Expression for the Diameter.

10. The diameter of conduits is very often the quantity we have to determine. The best method of obtaining it is by putting the fundamental equation under the following form:

$$\left.\begin{array}{ll}\text{[In metres]} & D^5 - \left\{{\cdot}00009594\frac{LQ}{H}D^2 + {\cdot}0826\frac{Q^2}{H}D + {\cdot}00222\frac{LQ^2}{H}\right\} = 0 \\ \text{[In feet]} & D^5 - \left\{{\cdot}00000594\frac{LQ}{H}D^2 + {\cdot}02518\frac{Q^2}{H}D + {\cdot}000677\frac{LQ^2}{H}\right\} = 0\end{array}\right\}\text{.(XIII.)}$$

We may pass over, for a first approximation, the first two terms in the brackets, and we have,

$$\left.\begin{array}{ll}\text{[In mètres]} & D = \sqrt[5]{{\cdot}00222\frac{LQ^2}{H}} = {\cdot}295\sqrt[5]{\frac{LQ^2}{H}} \\ \text{[In feet]} & D = \sqrt[5]{{\cdot}0006769\frac{LQ^2}{H}} = {\cdot}2323\sqrt[5]{\frac{LQ^2}{H}}\end{array}\right\}\text{(XIV.)}$$

This value will be rather small; and we must successively make slight augmentations to it, until the first member of the equation is reduced to, or equals, 0. The quantity which shall have led to this result will be the diameter required.

For velocities above 2 feet per second, we may take directly and simply

$$\left.\begin{array}{ll}\text{[In mètres]} & D = {\cdot}298\sqrt[5]{\frac{LQ^2}{H}} \\ \text{[In feet]} & D = {\cdot}235\sqrt[5]{\frac{LQ^2}{H}}\end{array}\right\}\text{..(XV.)}$$

I need say nothing on the determination of H and L; the equation (VII.) gives them by a simple transposition.

11. Let us take some examples of the determination of discharges and diameters:—

Ex. 1.—We have a conduit of (·25 mètr.) ·820225 feet diameter, and (1450 mètr.) 4757·3 feet long: required the volume of water it will discharge per second, with a head of (5·32 mètr.) 17·454 feet?

We have here $D = {\cdot}820225$ feet; $H = 17{\cdot}454$ feet; $L = 4757{\cdot}3$ feet; and $L + 37{\cdot}2\,D = 4787{\cdot}816$ feet. Consequently (X.),

$$Q = -\frac{{\cdot}0709\times({\cdot}820225)^3\times 4757{\cdot}3}{4787{\cdot}816} + \sqrt{\frac{1477{\cdot}06\times 17{\cdot}454\times({\cdot}820225)^5}{4787{\cdot}816} + \left(\frac{{\cdot}2325\times 4757{\cdot}3\times{\cdot}820225^2}{4787{\cdot}816}\right)}$$

$$= -{\cdot}047376 + \sqrt{1{\cdot}9989 + {\cdot}024155}$$
$$= -{\cdot}047376 + 1{\cdot}423 = 1{\cdot}37924 \text{ cubic feet per second,}$$

the quantity required (all the measures being in English feet). The simplified formula (XI.) would have given

$$Q = 1{\cdot}4185 - {\cdot}04767 = 1{\cdot}3708 \text{ cubic feet.}$$

That for great velocities (XII.), and applicable to this case, in which the velocity is 2·6 feet per second, would have given 1·357 cubic feet.

Ex. 2.—Required the diameter of a conduit, 2483·64 feet (757 mètr.) long, and which shall convey 3·14317 cubic feet (·089 mètr. cub.) per second, with a head of 3·2809 feet (1 mètr.)?

Putting these numerical quantities in the equation (XIII.), it becomes, all reductions made,

$$D^5 - ({\cdot}22827\, D^2 + {\cdot}075811\, D + 5{\cdot}0604) = 0.$$

Neglecting the first and second terms, we have

$$D = \sqrt[5]{5{\cdot}0604} = 1{\cdot}383 \text{ feet.}$$

This value of D, put in equation (XIII.), will be found too small; by gradually increasing it, we shall find, by a few trials, that the value 1·4127 feet for D, will reduce the first member of the equation to 0, and will be the diameter sought.

The formula for great velocities (XV.), and in this case v exceeds 2 feet per second, would have given

$$D = {\cdot}235\sqrt[5]{\frac{2483{\cdot}64\times(3{\cdot}143)^2}{3{\cdot}2809}} = 1{\cdot}383 \text{ feet.}$$

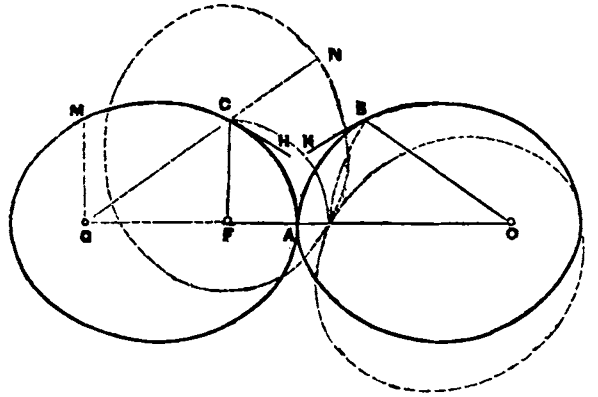
[We shall next month proceed to the author's consideration of conduits terminated by adjutages.]

REVOLVING ELLIPTICAL WHEELS.

Sir—Having had occasion to seek for some simple means of producing a variable motion of rotation round one fixed axis from a uniform motion round another, I have been led to observe a property of the ellipse, which as it was new to me, may perhaps prove so likewise to some, at least, of your readers.

It is, that if two equal and similar cogged wheels of elliptical form, be geared together as represented in the annexed figure (which is a drawing of the *pitch lines* of such wheels, without the cogs), the teeth will continue to act upon one another during an entire revolution, with perfect regularity; and the motion of the one axis will be transferred to the other—not uniformly, but subject to a variation in velocity, the nature and amount of which may be easily calculated. By such an arrangement, therefore, a variable motion may be produced from a uniform one, in a manner comparatively simple and easily available,—capable of transmitting a force of any amount with certainty and precision. There are, probably, many cases in which some such arrangement would be found convenient; and I am inclined to believe that it is not possible to find any more simple means of attaining the object.

The conditions which must be fulfilled in order that any two curves—supposed to act in the manner represented, from fixed centres of rotation—O and F, should continue in contact without any other than a rolling motion one on another, appear to be, that if we assume any two points, B and C, such that the arcs AB, AC, measured from the original point of contact A along the periphery of each curve, be equal in length:



1st. The sum of the vectors FC, OB, must be equal to FO; and,

2nd. That the sum of the angles FCH, OBK, made by the vectors with tangents at the points B and C, must be equal to π, or 180°.

For unless the first of these conditions be fulfilled, it appears plain, that when, by the motion of the axis at O, the one curve shall have assumed the position represented by the dotted periphery, the point B having been brought to the position B′, the point C would not be, as it should be, in contact; and if the second were not fulfilled, the curves would *intersect* at some other point, instead of having a common tangent at B′.

I need not take up your valuable space by entering into any detailed proof that these conditions are fulfilled by equal and similar ellipses working on foci, as a very slight acquaintance with the properties of the ellipse is sufficient to show that such is the case. That they may not possibly be fulfilled by some other more complex curves, I do not venture to assert, as the problem would be one of such extreme intricacy with regard to any other than equal, similar, and symmetrical forms; but I do not regard it as probable that any such curves can be found.

This principle would enable us to obtain motions of rotation of different *degrees of variation*, but of the same character—viz. with one maximum and one minimum velocity in the course of each revolution, according to the excentricity of the ellipses made use of. The revolution of the one wheel is necessarily conterminous with that of the other, but is described at a variable rate; the nature and amount of which variation may be readily ascertained, either analytically by means of the formula subjoined, or by the merely mechanical process of drawing an ellipse of the assumed excentricity, and drawing right lines from any point on the periphery to each of the foci; since it will appear plain, on consideration, that, for any assumed point C, CFA represents the angular motion at F due to the angular motion CGA, or BOA, at O.

To deduce an analytical formula applicable to the calculation of these angles, we take the polar equation of the ellipse with regard to focus G and origin GA, viz.

$$l = \frac{a^2 - c^2}{a - c \,.\, \cos\theta},$$

in which $a =$ semi-major axis, and $c =$ the linear excentricity.

Hence we find that the angle CFA, or ϕ, representing the angular motion round F, due to the angle CGA, or θ, round O, must be such that

$$\frac{a^2 - c^2}{a - c \,.\, \cos\theta} + \frac{a^2 - c^2}{a - c \,.\, \cos\phi} = 2a;$$

since, in order to fulfil the first of the conditions which we have shown to be required, H or Gm + Gc must be equal to FO or $2a$.

From this we can readily derive, by ordinary algebraical processes, the expression,

$$\phi = \cos^{-1}\left\{\frac{(a^2 + c^2) \,.\, \cos\theta + 2ac}{a^2 + c^2 + 2ac \,.\, \cos\theta}\right\},$$

a form easily calculated for any given values of the constants.

This action is far more simple, both in theory and practice, than that which has been already made use of—elliptical wheels working from the centres—the major axis of the one being placed at the commencement in the same straight line with the minor axis of the other. By combinations of the two, a variable motion of almost any regular periodic character may be attained, by due care in assigning the proportions of the constants; and great facilities thereby afforded for counteracting the effects of any irregularities in the motion of machinery which other circumstances may have induced.

In many cases it would be possible to economise power and space by such application; and in the hope that these hints may prove serviceable to some of your many readers, I have been induced to trouble you with this trifling communication, which you are welcome to deal with in whatever manner may prove convenient.

Southampton, **William Davison.**
February 20th, 1850.

P.S. Since writing the above, I have seen a small planing machine at Mr. E. P. Smith's engine factory, in this town, to which elliptical wheels, acting in the manner described, had already been applied, with ingenuity and success, to retard the forward motion, and accelerate the return motion, of the cutting tool. I was not aware that the principle had been applied; but as it is certainly far from being generally known, and as it appears to me capable of being applied in many ways with advantage, the publication of the above sketch, thus divested of all pretensions to being the first notice of the principle involved, may still prove useful.

Southampton, March 12th, 1850.

THE SMYRNA STEAM FLOUR MILLS
AND
THE WATT AND WOOLF STEAM-ENGINES.

With reference to an article on these subjects in our last number, we have received a communication from Messrs. Joyce & Co., of Greenwich, which we now insert, and to which we shall append a few observations. It is as follows:—

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

Sir—In your number for last month, which contains an account of the steam-engines and flour mills recently constructed by us for Smyrna, you have questioned the fact of those engines consuming "*less than 3lb. of coals per horse-power per hour;*" and add, that you cannot believe such a statement to have been made with our sanction; we should manifestly be wanting as well in a natural desire to do justice to ourselves as in a proper regard for our professional reputation, did we not avail ourselves of your pressing invitation, or challenge as we may rather call it, to verify or disclaim that statement through the medium of your columns. We shall therefore begin by saying that such allegation was made with our entire sanction. So far, however, from its being so extraordinary and unprecedented a performance as to have furnished grounds for your unqualified scepticism, we find *you* have long since borne testimony of having *witnessed* "*the gratifying fact*" "that a rotatory fly-wheel engine for land purposes can be made to do with *3lb. of coal* per horse-power per hour;" for if you will turn to your *Journal*, Vol. V., p. 109, you will find an article emanating from your pen, in which you report a double-cylinder engine constructed by Messrs. Rennie, and erected on the premises of Mr. Thomas Cubitt at Pimlico, to be working at 2⅓ lb. of Graigola coals per horse power per hour; neither is this "the full indicated power," but the actual duty, you yourself having deducted from the indicator diagrams an ample allowance for "friction, the power consumed by the pumps, &c.," a deduction which you seem to infer *may not* have been made in *our case*.

As the Smyrna engines could not have been put to work until after their erection at Smyrna, we cannot furnish you with any indicator cards of *their* performance; but we can, if you think it necessary, after reference to your notice of the Pimlico engine, hand you indicator cards of other engines constructed on this principle by us, from which you will see that the statement made by the public journals was a very moderate representation of their rate of consumption.

We do not profess, as you suppose, to have made any new or important discovery in the principle of double-cylinder expansion. All we claim is the simplification of the arrangements by which the number of parts, the weight of material, and amount of workmanship are proportionately reduced. Besides an obvious decrease of cost resulting from these improvements, it is manifest that the dispensing with several working parts, as the parallel motion, beam and its gudgeons, connecting-rod, &c., must, to some extent, (by reducing the friction, *vis inertia*, and momentum), economise power; and we think it requires no great stretch of credulity to believe that *some* economy of fuel must arise by these reductions from the arrangement in the Pimlico engine, and which you report to be working with 2½ lb. per horse-power per hour—certainly an excellent performance, but not in any way superior to our best engines.

Having said thus much in justification of our claim to notice, and in confirmation of some of the facts given in the public journals, we think it will not be out of place to advert, as an interesting matter of history, to some of your remarks when treating of double-cylinder expansion, especially as regards the first introduction of expansive steam, both in the single and double cylinder, or in what you have termed the "Watt and Woolf engines," as well as to some other observations you have made on the subject.

It ought to be more generally known than it appears to be, that the credit of having first propounded "double-cylinder expansion" is due to Jonathan Hornblower, and not (as you have assumed, and is very frequently supposed) to Arthur Woolf. Hornblower patented the system, with ample and efficient details, in 1781; that is to say, twenty-three years before 1804, the year in which you have stated Woolf published the discovery. The following abstract from Hornblower's specification will show that he fully describes this species of engine.

"*First, I use two vessels in which the steam is to act, and which in other engines are called cylinders. Secondly, I employ the steam after it has acted in the first vessel, to operate a second time in the other by permitting it to expand itself, which I do by connecting the vessels together, and forming proper channels and apertures whereby the steam shall occasionally go in and out of the said vessels, &c.*" The description and illustrations of Hornblower gave a complete arrangement of valves and other details, and rendered the system perfectly practical, so as to leave nothing wanting to the full development of the double-cylinder expansive engine. Most of what has since been done is due rather to the progressive advances towards a more perfect system of manipulation, and to that simplification and just proportioning of the parts which experience only could have warranted. What Woolf did was to bring a mind of a highly practical turn to bear on Hornblower's system, and in this he was so successful as to be fully entitled to rank as one of the first on the list of eminent constructors; for, although commencing as he did under a delusion and a fallacy, as regards the rate at which steam decreases in pressure while expanding, there is no doubt that it is entirely owing to his ready appreciation of the value of high steam when used expansively, and to the practical skill by which he made it available in the mining operations of Cornwall, in despite of practical difficulties and (more formidable still) of a *powerful* and *prejudiced* opposition, that Cornish mining has continued to be of its present extent and importance—since, but for the large reduction in quantity of fuel consumed by pumping-engines from what it was in the days of Watt, many now profitable mines must have been abandoned or remained unworked, as the cost of fuel would have exceeded the value of the ores, and precluded those further researches which have from time to time led to the discovery of the most valuable mining treasures. We may add also the more important fact, that it was in a great measure owing to the economical results as regards fuel, resulting from Woolf's success in Cornwall, that the expansive system has obtained so generally the sanction of our best practitioners, as is evinced by its almost universal introduction.

The pumping-engines of Cornwall are, with scarcely an exception, constructed on the principle of expanding steam in one cylinder; and *you* are *quite right* in stating, that the double-cylinder system is inferior for *pumping* purposes.

There is no question that single-cylinder expansion, IF the load can duly be proportioned to the effort of the steam from its first impact on the piston to its minimum of effective attenuation, will produce a greater absolute impulse, or, as it is termed, a better duty for the volume of steam consumed, than if the medium were a double cylinder. It is thus that the power of the single cylinder is given out in the pumping-engines of Cornwall; and whereby the consumption of coal has been brought as low as 1·75 lb. per horse-power per hour in the best example, for by the introduction of the plunger-pump, the power of the engine *is*, when the piston is subjected to the highest steam pressure (that is to say, before the supply from the boiler is cut off), exerted to overcome the *vis inertiæ* of the pit work, besides its unbalanced weight, the column of water being then at rest. Once in motion, the duty is that of overcoming little more than mere gravity; and ultimately the extreme expansion of the steam, as the piston approaches the bottom of the cylinder, serves to check the momentum of the pit-work. The column of water is raised on the return stroke, not by the direct effort of the steam, but by the gravity of the unbalanced weight of the pitwork. The piston of the engine ascending in equilibrio, as regards steam pressure, it will readily be perceived, that by these arrangements, the efforts of high steam at, and a little beyond, the commencement of the descending stroke, its subsequent expansion as the *vis inertiæ* is being overcome, and its gradual attenuation as it approaches the termination of its course (where the efforts of momentum and pressure should both be exhausted), is better and more simply, as well as more philosophically employed than it could be by the double cylinder; wherein the main distinctive feature is an approximation to uniformity of effort, and which is, on that account, so far inapplicable to the moving a load presenting the changes of resistance just stated.

It will be corollary to the preceding conclusions, that the importance of preserving a due relation between the power and the load, renders it as desirable that the power of a rotatory machine should preserve its uniformity, as that the power of a pumping-engine, under Cornish arrangements, should be unequal. Hence it is solely owing to this approach to uniformity of effort, that double-cylinder expansion possesses any advantages over the single cylinder whenever the power is employed to produce rotation.

We believe *you* will find you are wrong in stating, that single-cylinder expansion "is very commonly adopted in cotton spinning;" for, on the contrary, IF we are correctly informed, the employment of double-cylinder expansion is becoming very extensive in the cotton factories; and manufacturers are thereby enabled to spin cotton thread as fine as can be produced by water-power—a result wholly unattainable by single-cylinder expansion.

It is common to call the fly-wheel a reservoir of power, and it is quite true that it is so; but this property, imperfectly understood, leads to a popular mistake. The notion that revolving bodies must rotate uniformly, is so closely allied to our impressions regarding circular movement, that it is difficult to divest the mind of the idea that it is otherwise; and hence it is seldom duly considered, that to be a reservoir of power, the fly-wheel must have an intermittent velocity.

The fact, however, is, that so far from being, in any instance whatever (as it is frequently supposed) a perfect equaliser of unequal efforts, it is entirely owing to the necessary changes in its velocity that it becomes the reservoir of those excesses of power which arise from unequal impulses; since, as is obvious, such excesses can only be absorbed into the fly-wheel by the fly-wheel acquiring an increased velocity; and that they can only be given out again when required to overcome the load or resistance by losing the momentum due to the increased velocity, and consequently losing the excess of velocity the fly-wheel had acquired. Or it may be more clearly stated thus: the velocity, and consequent momentum of the fly-wheel, are conjointly increased or diminished, in an assigned proportion, as either the load or the effect to increase it are in excess.

We see, therefore, that however the dynamic efforts of expanding steam may economise fuel, its great inequality of effort, when given through the medium of a single piston, would forbid us to avail of that property to such an extent as to be of an appreciable practical value in cases where great uniformity of motion, as in cotton spinning, grinding corn, and several other delicate operations, are the prime consideration.

Even a perfect uniformity of effort on the piston, must, in all cases when applied to a reciprocating engine, entail some inequality of motion in the mill work. Such inequality, however, is reduced to a very small amount, by the employment of a pair of either single-cylinder non-expansive steam-cylinders, or of double cylinders acting expansively. We need not add, however, that the double-cylinder system must (as *you* have properly shown in *your* notice of the Pimlico engine) prove by far the most economical as regards fuel.

We are, &c.

Greenwich Iron Works,
March 18th, 1850.

W. JOYCE & CO.

⁂ Our professional brethren will not fail to perceive, that the letter by Messrs. Joyce and Co. is of a compound nature. In part, it is a reply to the remarks we made in our last number; in part, it is historical, and elucidatory of the action of the fly-wheel, and of the systems of pumping, as adopted in Cornwall;

in part, it accords with the opinions we have expressed; and, in part, it gives a tone and colouring to our observations, not justified by the statements we have made. Divested of extraneous matter, Messrs. Joyce and Co. candidly acknowledge to the following:—

That it was with their *entire sanction* and approval, our contemporaries asserted that in engines constructed by them, the consumption of fuel is less than 3 lb. per horse-power per hour; *while, under the old system, it is about* 12 lb.

That the Smyrna Steam Flour Mills had not been put to work in this kingdom (which, of course, is what we expected)—therefore, that the given rate of consumption, per horse-power per hour—*equal to* 3 lb., as above—was not the result of experimental tests made with those engines, but of other steam-engines made by the firm.

That they do not profess to have made any new or important discovery in the principle of double-cylinder expansion (nor did we suppose that they had contemplated making any such profession, notwithstanding their assumption to the contrary):—they state, therefore, all that they claim is, the simplification of the arrangements by which the number of parts, the weight of the material, and the amount of workmanship, are proportionably reduced; and, by which, there is a decrease in the cost of construction, and a diminution of friction, *vis inertiæ*, and momentum.

Messrs. Joyce and Co. acknowledge, that we are "quite right" in the statement we have made, that the double-cylinder system is, for pumping purposes, *inferior* in effect to the single-cylinder engine; and they append the following remarks:—"There is not a question that *single-cylinder expansion*, if the load can duly be proportioned to the effect of the steam, from its first impact on the piston to its minimum of effective attenuation, *will produce a greater absolute impulse*, or, as it is termed, *a better duty*, for the volume of steam consumed, *than if the medium were a double-cylinder*."

After these candid admissions, there are but few differences of opinion between Messrs. Joyce and Co. and ourselves. Those differences, however—few though they be—are of such importance, *practically*, that we must be permitted to make some comments.

Corroborative of the correctness of their statements, as to the superior yield of power by double-cylinder expansion, by a given consumption of fuel, over single-cylinder expansion, Messrs. Joyce and Co. bring to their aid some statements, published by us, in the *Journal* for April, 1842.

We feel much indebted to the Messrs. Joyce, for having drawn our attention to that article, published by us so far back as eight years ago. Messrs. Joyce and Co., however, in making reference to that article, have made an *ex parte* statement. They have, in that instance, and in others, when alluding to our remarks, shown more ingenuity than ingenuousness, by making it appear that our observations are *as they could wish them to be*, rather than as what they are. In illustration, we will make a few extracts from the paper published by us in 1842, which will develope a wonderful coincidence of opinion as entertained by ourselves, and impart quite a different character to the remarks we made, than what the extracts made by Messrs. Joyce and Co. would have a tendency to impress. Those extracts are as follows:—

"A certain quantity of the power which an engine exerts is exerted in overcoming its own friction, lifting the water which has accomplished the condensation of the steam out of a vacuum, &c. The term, horse power, is used to denote the available quantity of power which an engine is capable of furnishing for any useful purpose, and is, therefore, the excess of the power produced, over the power consumed by the engine itself. Any estimate of the power of an engine, based on the assumption that the whole power exerted by the piston is the true measure of the engine's beneficial exertion, is, therefore, fallacious. An allowance of one-eighth of the power as being consumed by the engine itself, is a usual and moderate allowance.

"The amount of economy to be obtained from steam working expansively *is precisely the same, whether the expansion takes place in one or two cylinders.* The use of two cylinders serves to equalise the action, and to diminish the strain thrown upon the moving parts; but it is questionable, *whether the greatest fluctuation of pressure, when only one cylinder is used, might not be rendered equally instrumental in the production of a regular motion, simply by using a larger fly-wheel, or driving the fly-wheel at a greater velocity; and whether it is not quite as simple to increase the strength of the moving parts a little, as to add an additional cylinder and piston*, to prevent them from being subjected to so great a strain."

Again:—

"In common rotative engines, *which operate without expansion*, the ordinary consumption of coal is 10 lb. per horse-power per hour. But the horse power" (of an engine, practically) "is usually found to be about 52,000 lb. raised one foot high, in a minute, which is equivalent to 26·208 millions raised one foot high by a bushel of 84 lb. of coal. Some good engines, however, operate with an effective pressure upon the piston of 13¼ lb. per square inch = 60,000 raised one foot high for a horse power; and a few ascend as high as 66,000 per horse power, without employing high-pressure steam. The engines consume *about* 8 lb. *of coal, per nominal horse power*, or 4 lb. of coal per horse power of Watt. The consumption of coal, in this engine" (the Messrs. Rennie's, or the Pimlico engine) "is 132·3 lb. per hour $\frac{132 \cdot 3}{52 \cdot 78}$ = 2·5 lb. per horse power, per hour."

In the preceding extracts, it will be perceived that we have made a marked, and an unerring distinction, between the *nominal* and the *actual* duty of steam-engines, and the quantities of coal consumed in either case; and that we have stated the average consumption of coal, in the best engines, to be 8 lb. per horse-power per hour when estimated on the nominal, and 4 lb. when estimated on the actual power. And we have further qualified our statements, with respect to the duty of Messrs. Rennie's engine, by stating that when, for the actual duty of the single-cylinder engine, the consumption is 4 lb. per horse-power per hour, it is at times when the steam is not expanded, and not at high pressure, both of which, when combined, would reduce the amount of fuel as usually consumed.

These statements are very different to those made with the expressed sanction of Messrs. Joyce and Co., which make it appear that their engines consume less than 3 lb. per horse-power per hour, "*while engines under the old system consume about 12 lb.*;" and which, as it was likely to mislead the public, called forth our remarks and animadversions. If 12 lb. per horse-power per hour be given on the *nominal power* of the single-cylinder engine, so also ought the 3 lb. on the double-cylinder. It ought, also, to be borne in mind, that the consumption of fuel, as given by Messrs. Joyce and Co., is for double-cylinder *expansion*, with high-pressure steam, and for single-cylinder *non-expansion*, with steam of low-pressure—a statement much in their favour. We therefore cannot accord with the final observation in the Messrs. Joyce's letter, "that the double-cylinder system must prove by far the most economical as regards fuel." Nor can we give our sanction to the statement made by them, that we have very properly shown that it is so. Our opinions, as published in 1842, and those recently avowed, forbid any such interpretation of our thoughts, and are diametrically opposed to any such construction of them.

The 'Treatise on Mechanics,' by Dr. Olinthus Gregory, is in the libraries of most engineers; therefore, the merit due unto Hornblower, and the controversy between him and Messrs. Boulton and Watt, are well known. Still, as Woolf brought the double-cylinder engine into practical operation, it is customary with practical men to denominate such construction, the "*Woolf-engine*." In the article to which Messrs. Joyce and Co. have referred, as published by us in 1842, we have given unto Hornblower his full meed of praise for that invention. We think, therefore, it is scarcely fair of Messrs. Joyce and Co. to assume that we were ignorant of the matter, with that article before them. In the papers of several of our contemporaries on the *Smyrna Steam Flour Mills*, which appeared with the express sanction of the Messrs. Joyce, and which we reviewed in our last number, it is called the "*Woolf-engine*," not the Hornblower; therefore, out of deference to them, and to public opinion, we gave unto the double-cylinder-engine its usual denomination.

Messrs. Joyce and Co. must pardon us for giving an unqualified contradiction to their construction of our statement, "that single-cylinder expansion is very commonly adopted in cotton-spinning." We said nothing of the kind. What we did say was this:—"*the expansive system is now very commonly adopted* to rotatory fly-wheel engines *by our best engineers*; and we ourselves were principally instrumental to its *first adaptation* to the delicate processes of the cotton manufacture." Our language, therefore, will not admit of any such twisting. We are aware that Mr. MacNaught, as stated in our last number, and that highly eminent firm, Messrs. Benjamin Hick and Son, of Bolton-le-Moors, Lancashire, are re-introducing, with certain modifications, the double-cylinder expansive engine, and applying it to cotton-spinning processes. But we must be permitted to entertain the opinions we avowed in 1842, and reiterated in our last number, as to the relative merits of the Watt and Woolf steam-engines, until we be furnished with data of the most unquestionable kind, as to the superiority of the latter.

In concluding, we must state our opinion that, although we differ from them in opinion, and they have, in some instances, given a tone and colouring to our statements not warranted by facts, we think much merit is due to Messrs. Joyce and Co., as constructive engineers and makers of steam-engines, and for the candour of their present communication.—Ed. C.E. & A. Journal.

REVIEWS.

Bombay Cotton, and Indian Railways. By Lieut.-Col. C. W. Grant, Bombay Engineers. London: Longman, 1850.

It seems hard to say that this book is a good one, and that we set ourselves against it; and yet it is what we are bound to say. Colonel Grant advocates a line from Bombay by Poona, in preference to that by the Malsej Ghaut: but we withhold ourselves from going into that, for though the fight may seem to be about one Ghaut or another, in truth, the whole business of railways in Western India is at stake.

The great evil hitherto has been the standing still: the government have at length been got to give leave for something being done: and it would be nothing short of madness to open the business again. The government are bound to the Great Indian Peninsula Company, and a line has been laid down for the Malsej Ghaut; and now, after so many years lost—aye, even this year lost—a beginning must be made. It may very well be said that the line by the Malsej Ghaut is the worst that could be chosen; but it has been chosen, and we must stand by it. The Colonel says—

"Sera nunquam est ad bonos mores via:"

but though it may never be too late to mend, we must say this time, it is never too early to begin. Already, a Hindoo king has undertaken a tramway from Baroda to Tankaria Bunder; and once get a railway going, other kings and other monied men will be brought to take a share in carrying out Indian railways. If the Colonel be followed, we shall have, as before, several years lost; and what may be the end no one can tell. Perhaps his railway by the Bhore Ghaut might go on—perhaps, after all, that by the Malsej Ghaut would stand good: but what is most likely, railway men in England and India would be so sickened, that no money would be forthcoming.

What was to be looked for has happened; once hold out a hope of railways for India, and every one wishes to have them in his own neighbourhood, and nowhere else, if he can help it. Col. Grant speaks out for Poona, one of the greatest towns in the west—the next to Bombay, and, as it may be said, the first step inland. We think there ought to be a Bombay and Poona railway—we strongly believe there will be one; but nevertheless, we do not wish the Malsej Ghaut line to be stayed to forward a railway to Poona. Indeed, we believe the making of the Malsej Ghaut line the best way for hastening one to Poona. Colonel Grant himself throws some light on this. Make the Great Indian Peninsula Railway, and a Poona line will be made. If, indeed, the business be opened afresh, and Poona should win the day, still five or six years will go by before anything is done; whereas, if the Great Indian Railway be opened in that time, such a start will be given, that railways must be made to Poona, and wherever they are wanted.

Colonel Grant is a man of high standing, and of great knowledge, and has fought well for his side; but we shall neither step in for him or against him. We shall leave Mr. Chapman, the founder of the Great Indian line, to answer for himself and his undertaking. All we care for is, railways for India; and that we think is best got by upholding the East Indian and Great Indian Peninsula Railways. Holding back, as we do, from the Colonel's plan, we must not be misunderstood, and thought to withhold our meed from his book. It is one of the best which has been written on Indian railways, and one our engineering brethren ought to read, as the writer having a deep knowledge of what he is about, has thrown great light upon it. He is wholly for cheap works and light engines; and he goes at some length into the details of building and working, not being one of those who pull down without setting up something in its stead. His is a book, indeed, which upholds the credit of the Indian engineers, and shows how ready our eastern brethren are to keep up their professional knowledge, and carry out everything which is new and good.

What Colonel Grant says when writing about cotton, will be read with some interest, as showing the great income got from the water-ways of India. Colonel Grant himself shows how cheaply a water-way could be made in Guzerat, between the Taptee and the Nerbudda, so as greatly to further the growth of cotton; though, as the Malsej Ghaut Railway has been put forward as a cotton railway, the Colonel, on behalf of the Poona people, wishes to show that the great cotton field is not inland, but in Guzerat. After all, he allows that railways would do some good for cotton.

The Geography of Great Britain. Part I. England and Wales. By G. Long, M.A., and G. R. Porter; the Statistical Division by Hyde Clarke. London: Baldwin, 1850. Octavo.

An exceedingly cheap and perfect work, containing a complete physical geography and political topography of England and Wales. It is of great consequence that an engineer should be acquainted with the physical geography and geology of a country, more particularly of that one of which he may be an inhabitant. In this work the rivers, valleys, mountains, and other physical characteristics are fully described. The climatology of the country has not been forgotten, and several interesting tables are given. The importance of this subject has been recently impressed on our readers by a writer in the *Journal*. Each county, with its principal places, is described with great clearness, while at the same time a full description of the trade, antiquity, and population of each place is given.

We cannot speak too highly of the statistical portion, which contains a complete view, in a condensed form, of the whole body of statistics relating to England and Wales, brought up to the present time. The population of every town, including all the new ones, is given, which is very useful. The ordinary returns merely give that of the parish, which is generally of no service, it being very different from the actual town population, which is what is required for statistical purposes. Every department of trade is attended to, the imports and exports of every article being mentioned, with the number of persons employed. The number of professional men returned for England is 117,697, architects and engineers bearing the respective proportions of 1,458 and 828. The index is well arranged, which is a point of considerable moment in a work of general reference.

Suggested Legislation, with a View to the Improvement of the Dwellings of the Poor. By G. Poulett Scrope, Esq. M.P. London: Ridgway, 1849.

Mr. Poulett Scrope has distinguished himself by the promotion of practical measures for the benefit of the working-classes, and particularly with regard to dwellings. Certainly, one of the first things to be done is to have good house-room for the whole people, and it is quite within the power of our lawmakers to do this, if they honestly wish it. Brick, stone, and lime are to be found all over the land; there are workmen enough; and, so far as that goes, a palace might be built for every one in England. There is the same plenty of material for schools and churches. There is no industrial stumbling-block.

Mr. Poulett Scrope proposes three measures—First, to exempt small tenements from rating; next, union rating; and third, facilities for granting cottage sites. The first has become a purely political discussion, and is beyond our bounds; the next may be considered a measure affirmed by the common wish, and on its way to accomplishment; the third is a step which nothing but the blindness of lawmakers can long hinder.

At length the duty has been taken off bricks, which will do something for carrying out Mr. Scrope's wishes; and we have great pleasure in congratulating the profession on the putting-down of this hurtful tax. Not only was it a hindrance in the way of enterprise and of art, but it kept thousands out of employment. It will be none the least benefit from getting rid of the excises on bricks and glass, that a great field of employment has been opened; and the next steps are abolition of the taxes on paper, carriages, and men servants—all of which, instead of being levied on luxury, are in truth levied on industry. The trade of cariage-building however high it stands in this country, is much kept down by the taxes on carriage-owners, to the great loss of masters and workmen.

Architectural Sketches—Italy (drawn on the spot by the Author); comprising Villa Outlines, Doorways, Gateways, &c. By T. C. Tinkler, Architect.

We presume from the title that it is Mr. Tinkler's object to give other illustrations of his architectural tour, besides Italy. The present part contains many designs of interest; but we would suggest to the author, as there are so many inquirers into authorities for Italian villa architecture, that it would add much to the value of the work if more details were given, and, in some cases, plans.

Architectural Publication Society. Part I. New Volume.—The part now out is an earnest for the volume of 1849-50, showing that good faith will be kept with the supporters of the Society, while it is announced that a second part is in progress. Among the present subjects of illustration are Catacomb, Corbel, Façade, Furniture, Loggia, Screenwall, Staircase, and Tomb, and a coloured plate is promised with the next part. Many examples are given which will be new to the profession.

On Copyright in Design. By THOMAS TURNER, Esq., of the Middle Temple.—A work which contains much useful matter on a subject now of great interest to the mechanical classes. We would suggest to the author, that in a second edition an index should be added.

Counsel to Inventors of Improvements in the Useful Arts. By THOMAS TURNER, Esq., of the Middle Temple.—A popular and amusing dissertation on patents and inventions, with many anecdotes.

Buildings and Monuments. By G. GODWIN, F.S.A. Part VI.—We have already spoken so frequently in commendation of this cheap and useful work, that we can do nothing more than record its progress.

Hints on the Valuation of Ecclesiastical Property.—A useful little work, explaining the nature of ecclesiastical property, the valuation of which is necessarily not understood by the profession generally.

ON FURNITURE AS A BRANCH OF DECORATIVE DESIGN.

[FIRST ARTICLE.]

WERE the matter itself regarded and treated as one of no importance—were we content to abide by usefulness and convenience, without aiming at anything further, we could not expect that any study should be given to the subject of Furniture, as a branch, though perhaps a subordinate one, of artistic design; but as precisely the reverse is the fact, and as next to architecture furniture affords opportunities for exercising taste and invention, and that not only occasionally but daily, it is somewhat surprising that nothing whatever has been written concerning it, beyond a few random and incidental remarks. Neither Hope nor Percier have entered into the subject, or attempted to lay down any guiding principles of correct taste; but have contented themselves with merely exhibiting their designs, and prefacing them by some desultory general observations. Tasteful, too, as their designs are upon the whole, they betray not a few incongruities, and, in some instances, a most disagreeable mixture of excessive plainness with excess of ornament. Speaking generally, furniture-design may be said to be made altogether a matter of empirical practice. We frequently see very great skill of workmanship and great beauty of material expended upon objects of the kind, with scarcely any attention to elegance of form; the last being in some instances completely marred by ornament that serves only to enhance both labour and cost. With both the producers and the purchasers of furniture, sound good taste is but a very secondary consideration; while the former look chiefly—and naturally enough too—to their immediate interest as manufacturers and tradesmen, the others consult only fashion, or are guided by individual fancy alone. Neither party is capable of properly directing or correcting the taste of the other; nor is it strange that such should be the case, when furniture is looked upon as having nothing to do with art, or art with it, but as being altogether lawless, and when with regard to "taste" means little more than "whim."

Some there are who are either quite indifferent to everything connected with *ameublement*—as was, for instance, Goethe, although otherwise by no means destitute of *formen-sinn* and æsthetic sensibility—or else affect to despise all such matters as partaking of frivolity and effeminacy; and we may very safely leave them to enjoy their philosophical contempt, there being no danger whatever of its becoming an epidemic. We ourselves adopt Mr. Fergusson's philosophy: "At present," says that able writer and original thinker, "the art (viz. of furniture) is entirely in the hands of shopkeepers, and, of course, has no right to the rank which I have assigned it. Yet there are instances even in this country, and at the present day, where one presiding mind, under the guidance of good taste, has taken the requisite trouble to elaborate the whole design, and where the carpets, curtains, and furniture have been grouped into a whole of no small beauty and elegance. It is not a high art, but it is one capable of a very considerable degree of refinement; and from the circumstance of its being an absolutely necessary one, and its objects always present, it is capable of exercising no small degree of influence on the tone of the mind, according as refinement or vulgarity may predominate,"—which doctrine, we may observe, has been successfully carried out practically by the writer himself in his own tastefully fitted-up and embellished residence.

After all, it will perhaps be said, all objects of the kind soon grow familiar to the eye, and cease to afford any positive enjoyment. The charm of novelty, of course, wears away, the first emotions of vivid delight gradually sober down; but so is it with a prospect, however beautiful, which is daily viewed from one's windows. In the one case as in the other, the charm of novelty is succeeded by the more quiet and silent gratification of habit. An atmosphere of taste and artistic beauty is produced, whose cheering influence is permanently felt, although it is what is unnoticed, and also what hardly admits of being explained. All, indeed, that recommends itself by the mere vogue of fashion, or by glare, glitter, and showiness alone, soon palls upon the eye,—we become cloyed with it, and wish for change. Really good taste, on the contrary, carries with it a permanent charm, and a nameless fascination. Such taste, too, is, *cæteris paribus*, the cheapest and most economical of any—albeit, not very cheap in one sense, since it is not to be bought; there is no mart where it is sold ready-made. Still, it is in itself the most economical, because capable of producing effect with the minimum of means—never wasting any of the means at its command; and also because it never stales, but possesses an endurable power of charming. Independent of mere fashion from the first, it never becomes "old-fashioned," like that which, destitute of intrinsic artistic merit, recommends itself only by being in the passing mode of the day, admired for a brief while, and then not only discarded, but perhaps held up to derision and ridicule. Time settles a good many questions of taste; notwithstanding which, there is just now a most unfortunate disposition to revert to much false and even depraved taste which, whether on that account, or merely owing to the changes of fashion, had very deservedly been exploded, yet is now again brought into vogue by the prestige of names—Renaissance, Elizabethan, Louis Quatorze, &c.—and in consequence of the demand for novelty, while our designers and manufacturers, unable to produce it—incapable of extracting what is good in former styles of decorative art from their mere dross and rubbish—merely serve them up again, with less of invention and skill than a cook shows by converting the remains of a cold joint into a savoury hash.

Good taste, again, is the most economical, because it works according to the means and resources at its command; making the most of the means afforded it; never attempting more than can be carried out consistently by them. It knows precisely how far it can go without breaking down; it never errs on the side of too much; still less does it jumble the "too much" and the "too little" together, as is frequently done; and if but little can be accomplished, it will make that little appear to be the "quite enough." Wasting nothing, it allows nothing to appear wanting; but working with well-understood purpose, and putting everything in its proper place, it makes every stroke tell. To all that it does we may apply Pope's well known line:—

> "And not a vanity is given in vain;"

taking vanity in the sense of ornament, which is more than can be generally said of the taste of "decorators" and their employers; for theirs is apt to remind us too forcibly of the "all is vanity." With them, elaboration and ornament are everything—at once their *forte* and their foible—their strength and their weakness; while of character and expression, artistic effect and *ensemble*, they take no account. They are in decoration what Denner was in painting—we marvel at the pains-taking hand, but we miss the artist-mind. Such minikin taste seems to be just now gaining vogue; for although decorative art and ornamental design are much talked about, they seem to be very imperfectly understood, and to be taken up on wrong principles, if upon any principles at all.

Now, in our opinion, ornamental design means a very great deal more than the merely designing ornament, details, and patterns, which are afterwards applied at random to anything and everything indiscriminately. Our designers and artisans seem to endeavour to conceal their poverty of invention, crudeness of taste, and inability to produce graceful and fresh combinations, by a profusion of unmeaning, fantastic ornament, which rather encumbers and disguises than embellishes, though it very seldom conceals the insipidity or else the positive ugliness of the article to which it is applied. Most of the designs for furniture and manufactures which have appeared in the *Art Journal*, are open to such censure; and even the best of them show very questionable and so-so-ish taste, and borrowed ideas—borrowed, moreover, from the worst school, that of the so-called Rococo; wild and capricious, yet imbecile and dull. Instead of grace, or any approach to it, we have only grotesqueness and grimace—incoherent shapes tortured into such deformity that only the intrinsic beauty of material and colour, together with the fictitious value of cost—which is often in direct inverse ratio to æsthetic value—can render them endurable to the eye. No doubt very serviceable lessons may be derived from corrupt modes and fashions of design, because from them we may learn what are the faults and errors which are studiously to be shunned.

In all those modes which, however they may be distinguished from each other, come under the general denomination of Rococo, the taste shown is so very coarse, and the faults so gross, that it might be thought the slightest degree of æsthetic feeling would deter from re-adopting them at the present day, *after* we have become acquainted with specimens of both classic and mediæval design, which are infinitely superior. Such strange perversity is to be accounted for only as verifying the remark, that

"*L'ennui du beau améne le gout du laid.*"

The perversity becomes all the greater because accompanied by inconsistency: with us the preposterous taste which there is now an unfortunate disposition to revive, is no longer costume, but mere masquerade, put on at the bidding of fashion. So long as it was costume, it extended to everything alike—not only to furniture and interior decoration, but to architecture itself; to equipages and carriages, to dress, and to gardening. The human form was disfigured by the most extravagant and absurd attire; and nature itself metamorphosed, as far as it could be, by the operation of the shears, and the application of the line and compasses. In all things alike, the unnatural was mistaken for the artistic; the only difference being, that while the natural was made to imitate the artificial, the artificial was made to imitate the natural. Execrable as such false taste must be pronounced, there were excuses for it in its own day, which no longer exist; because then, instead of being taken up for the nonce, ready made, it grew up conformably to circumstances. Clumsy and barbarous as it was, it was not a *relapse* into what had been discarded; which kind of falling back upon what once had vogue, merely on account, perhaps, of the name it bears, and the reminiscences attached to it, is a totally different matter from reverting to it for the purpose of studying and appropriating to ourselves its better qualities. To adopt by-gone tastes and fashions by taking them just as we find them, is like transplanting dead trees. Our own ideas being exhausted, we are fain, for the sake of a little temporary novelty, to resort to such as had been worn out previously, and into which we are incapable of infusing the vitality and spontaneousness requisite for reviving more than merely nominally any past style.

Had we any fundamental and rational principles of taste, the sudden changes of fashion, now so frequent, from one extreme of taste to another, could not occur. Change there still would be, but it would be gradual, natural, progressive—the result of improvement, and regulated by motive. At present, those who are artists do not attempt to guide or regulate the taste of the public in those matters which, however influential upon a correct feeling for art generally, are not immediately connected with their own pursuits and practice. Architects themselves do not bestow any study upon furniture and fittings-up, or on other internal decoration than what actually belongs to construction. They do not qualify themselves even for superintending such matters, but turn them over entirely to those who, however clever they may be in their way, are rather artisans than artists—very capable of executing, but seldom capable of designing more than piecemeal ornament and detail. No wonder, therefore, that we so seldom find completeness of *ensemble* and due artistic keeping in even the most sumptuously furnished apartments. Every separate article or ornament may be irreproachable in itself, yet the reproach of unequal and careless, if not actually bad taste, may be deserved by the discordant assemblage of them. An upholsterer's show-room, or a furniture bazaar, or a curiosity shop is one thing, and a tastefully furnished room quite another. Fashion, however, can sanction the most palpable absurdities and extravagances; and at Paris, it was for a while, in the time of the Consulate, the fashion to assemble in the same room a congress of chairs and other pieces of furniture, all differing from each other; a whim so outrageous, as to be excusable only as a satirical symbolisation of political chaos and conflict.

In his highly interesting comparative view of the *material* state of society in England, and its progress since 1685, Mr. Macaulay has omitted to touch upon the subject to which we are rather calling attention than pretending to treat of it formally. Yet it is what was surely not wholly undeserving of a few touches of his graphic pen, more especially as there is now a hankering after what smacks of the *perruque*, or even of Queen Bess's ruff or farthingale in *ameublement*,—which is, in our opinion, of evil augury to sound taste. In a *bonâ fide* old English mansion, contemporary furniture that has been a heir-loom for successive generations, is in its place, and in keeping with all the rest. It possesses there an historic value which reconciles us to its want of elegance. Its cumbrous stateliness, and even its clumsiness, is quaint, and carries with it an air of the formal aristocratic dignity affected in by-gone times. There it is genuine costume, and impresses us like the graphic descriptions of similar interiors and their accessories in Scott's novels. In Dutch pictures again, and in Hogarth's plates, the furniture and fashion respectively exhibited in them are the characteristic stage-properties of the scene; but to imitate things of that kind now-a-days, amounts to a confession that we have learnt nothing whatever from all that we have become acquainted with, have studied, or pretended to study, in the interim; but are just as far off as ever from having any settled and rational standard of taste. Nay, after having cheated ourselves into the belief that we were beginning to appreciate and arrive at a degree of refined elegance previously unknown to modern times, we are fain to relapse, by way of change, into the fulsome tawdriness and gewgaw fancies of the Louis-Quatorze and Louis-Quinze periods, which, if they can lay claim to the name of style at all, may be classed with that of the pastrycook and confectioner. Such mode of decoration takes cognisance of adscititious ornament alone, and makes that consist of nothing more than mere scallopings, crimpings, and zig-zags; so that in spite of its seeming variety, it is essentially monotonous, and even its very freaks betray barrenness of invention. It is capable of but one expression, that of arrogant, purse-proud pomposity.

Instead of turning to such radically vicious and tasteless manner, we should do better to go back to the days of Adam at once—of Robert Adam we mean—who, prosaic and feeble as was his taste in architecture, did something to improve the general style of furniture. Praiseworthy it certainly was in him to endeavour to place that subordinate branch of design upon a much more artistic footing than he found it. It is one, however, that requires talent of a peculiar kind; nor is it every architect who could descend to it without falling also, even if he would *condescend* to make the attempt. Heideloff, for instance, has done much for the illustration of German mediæval architecture, yet has failed most signally in his designs for Gothic furniture, most of which violate every principle of convenience as well as of beauty. The taste which he has shown is so truly detestable as to be harmless, since it can hardly fail to disgust at first sight; and yet we ought to have our doubts as to that, when we find such portentous monstrosities paraded as "admirable designs in furniture," in an English publication which professes to watch diligently over the interests of every department of art.

REMARKS ON THE SANITARY LABOURS
CONNECTED WITH THE
DRAINAGE OF THE METROPOLIS.

> "When we inquire what facts are to be made the materials of Science, perhaps the answer which we should most commonly receive would be, 'TRUE FACTS,' as distinguished from any mere inferences or opinions of our own."—WHEWELL: 'Philosophy of the Inductive Sciences.' Vol II., B. 11, p. 193.

Thirty years have now elapsed since the inquiry, instituted in 1819, respecting the supply of water to the metropolis, led Mr. John Martin the artist, to the consideration of our water supply—the relieving the River Thames from its impurities—and the preserving the sewage for agricultural purposes[1]—the three most important points connected with the present metropolitan drainage question.

While it is to be deeply deplored that more successful means have not been found or adopted for the more speedy alleviation of the evils afflicting the public health of the metropolis generally, but more particularly of that portion of the labouring population which, for want of time and means, are unable to avail themselves of such private remedial measures as are within the reach of the comparatively richer part of the community, we cannot conceal

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[1] See Second Report of Select Committee on Metropolis Improvements. Quest. 1867, p. 148. 1838.

from ourselves, after a due examination of the merits of the labours which have put us in possession of the conflicting opinions, and, in the majority of cases, valuable evidence embodied in the Reports of the several Commissions, instituted at different times with a view to ameliorating our sanitary condition, that though the progress of improvement has been slow, it has been *sure*—though not marked by many of the results we had a right to anticipate. That so great a delay has occurred, is not, therefore, to be attributed to the want of talent and exertion on the part of the public bodies appointed to examine the special means requisite; or of ability—so far as the resources of the present existing state of certain branches of science admit of—of our professional men, a large portion of whose contributions embody, perhaps, the most valuable additions that have been made of late years to engineering science generally; but in some measure to the want of such *data* as cannot be obtained from the testimony of former experience or former practice, and concerning which the Commissioners have only been able to elicit conflicting opinions, the more difficult to decide upon, there being at least a somewhat general agreement among the witnesses, as to the inappliancy of received formulæ as guides for the framing of future plans—thus setting aside not only the practice, but also the received theory of former years.

The summary of the questions to be settled before any proposed system can be generally deemed advisable, includes, on account of this disagreement of opinions, a great number of heads, respecting which further investigation becomes consequently necessary; and in order to obtain indisputable conclusions on the majority of these points, such investigations ought to be founded on trials, when possible, of the respective merits of the different proposals made for effecting the same objects, where so proposed, or deduced from correct experiments when the same practical means are advocated; but a diversity of opinions exist respecting the theoretical means of application of such practice, whether in the shape of formulæ or otherwise, to varying circumstances, simply dependent on mere local circumstances.

For instance—Mr. W. Hosking[2], Professor of Architecture in King's College, and Mr. John Phillips[3], C.E., Surveyor of Sewers, advocate the oviform sewer with the small end downwards; on the other hand, Mr. Joseph Gwilt[4], Architect, Surveyor of the Lambeth District of Sewers, and author of various works, one on the strength of arches, which "has passed through three editions;" and another, a complete encyclopædia of architecture—of construction in all its branches, prefers turning the oviform drain of the abovenamed gentlemen upside down; and argues the advantages of the big end over the little end for the lower side of the section, but favours more particularly the vertical-sided form with semicircular top and bottom; while the late Mr. Butler Williams[5], C.E., and Mr. Henry Austin[6], Secretary of the Board of Health, express their opinions in favour of circular drains. Each of these advocacies is duly backed by mathematical reasons of some kind or other (we say of some kind or other, since they cannot possibly all be correct); and as the matter to which they relate belongs to the *mixed* instead of the *pure* mathematics, it becomes extremely difficult, nay, impossible, without actual proofs of demonstration, to give such a judgment on any such point as would be deemed satisfactory by all.

In the mere examination of a witness, there are difficulties to contend with. The following is asked:—

> "Have you had any experience, or would you state it as a result of which you have no doubt, that an egg-shaped sewer, with the broad end downwards, will, with the same run of water, discharge more quickly, and keep itself clean better than an egg-shaped sewer with the narrow end downwards?—I should say it would clear itself better because there would be less friction upon a circle than there would be on the parts of an ellipse [7]."

Here we have a question, which at first sight seems clear, important, and well put; but which is, in point of fact, essentially faulty, inasmuch as the answer is a variable one, dependent on the very condition left out, viz., the *height* of flow in the oviform section, "the same run of water" not being a sufficient condition, admitting at it does of the very opposite answers, according to the circumstances of "quantity" left out. We proceed with the evidence:—

> "Do you not think, that is a fact which may be determined by actual experiment?—No doubt it may."
>
> "And ought not it to be?—I can see no objection to it whatever."

A dangerous question cautiously answered. A simple unguarded affirmative answer would have been an admission of *doubt* on the part of the witness; but here the answer implies, "If you wish it for your own satisfaction, well and good: as to myself, I am perfectly satisfied as to what the result would be." Consequently we obtain a decided unconditional answer to a question, which, not being sufficiently explicit, only admits of a variable one.

We have brought forward an instance, out of many others, to show how difficult it is to deal satisfactorily with matters of this kind; and how essential it is to do our utmost to divest ourselves of all prejudices we may possess for or against any opinion at all likely to influence our decision. Unfortunately, ours are many and deeply-rooted. Our pure mathematics are indisputable—their proofs incontrovertible; but their practical application to the arts of life and civilisation, requiring *data* derived from observation and experiment, engenders difficulties which render the investigation of the applied sciences often perplexing—too often intractable. Hence the origin of what are termed "false theories"—of the diffidence generally shown towards opinions purporting to be new—hence the great distinction made between theory and practice—itself a false notion. The *mixed* sciences, as the term implies, require, less or more, certain admixtures of the "pure" and the less certain—of the theoretical and the practical; any bias of the mind, therefore, in favour or against either of these, theory or practice, as regards "applied" cases, does not only come under the head of prejudice, but is, besides, a false impression; since, correctly speaking, neither can be used independently of the other in any such application. We can no more progress in the theoretical investigation of any branch of mixed science, without experiment and observation, viz. practice—requiring, as we do, "new" facts to build upon—than we can hope to obtain "general" conclusions from mere practice, without inductive reasoning; since "experience cannot conduct us to universal and necessary truths: not to universal, because she has not tried all cases—not to necessary, because necessity is not a matter to which experience can testify." And, therefore, we must insist as strongly against the practice not founded on theory correctly induced from facts, as we do against theory not founded on facts correctly deduced from experience.

When we consider the many difficulties attending the investigation of "truth"—when we reflect on the slow progress of some of the inductive sciences—on the too frequent want of necessary data—and that hydraulics is, perhaps, of all the physical sciences, that respecting which the least satisfactory results have been obtained, after having occupied the attention of some of the leading minds science can boast of—when we bear in mind the difficulty of introducing new views, however plausible—of the prejudices existing in favour of received practices, however faulty, we cannot wonder that the question of the means of an efficient drainage of the metropolis is still an undecided one; although, from a careful examination of the labours of the Sanitary Commissioners (as we have already said), we cannot but allow that they have done much that was necessary towards the end in view—much for which the next generation of engineers will thank them.

In consequence, partly, of the difficulties we have thus briefly alluded to, thirty years have elapsed, as we said before, since Mr. Martin's attention was first directed to the three most important questions connected with the drainage of London, without any decision having been come to respecting either of them, though the labours instituted by the legislature have, of late years, been incessant. His opinions, however, were not published until 1828, when his "first suggestion for not only relieving the river from its impurities, but preserving the sewage for agricultural purposes," appeared. In 1830, Mr. Ainger, the then conductor of the *Gardeners' Magazine*, published in that work his plan for "preserving the purity of the Thames, by constructing covered drains along the sides of the river to receive the minor drainage." Shortly afterwards, the proposals for improving the banks of the river were submitted to the Committee for Improving the Navigation of the River Thames, whose Report was presented to the Court of Common Council, 3rd August, 1832, and contains some useful information on the questions of embanking, and the formation of quays. In July, 1834, Mr. Martin presented to the Select Committee of the House of Commons, appointed to inquire into the law respecting Metropolitan Sewers, his plan, published in 1828, the objects of which were described to be—"1st, to materially improve the drainage of the metropolis; 2nd, to prevent the sewage being thrown into the river, and to preserve in its pure state the water which the inhabitants are necessitated to use; 3dly, to prevent the pollution of the atmosphere by the exhalations from the river, and the open mouths of the drains; and, 4th, to save

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[2] First Report of the Health of Towns Commissioners. Quest. 369, p. 39.

[3] First Report of the Metropolitan Sanitary Commissioners. Evidence, No. 13.

[4] First Report of the Metropolitan Sanitary Commissioners. Evidence, No. 20.

[5] First Report of the Health of Towns Commissioners. Quest. 5828, p. 380.

[6] First Report of the Metropolitan Sanitary Commissioners. Evidence, No. 23.

[7] First Report of the Metropolitan Sanitary Commissioners. Evidence, No. 20, p. 101.

and apply to a useful purpose the valuable manure which is at present wasted by being conveyed into the river." On the 18th of June, 1838, he was examined before the Select Committee appointed to consider plans for the Improvement of the Metropolis; and on the 11th of July following, his matured scheme of his parallel sewers—the first idea of which, he tells us,[8] was originally published in 1829—was communicated by him, in a Report to the Committee. About this time, Mr. Thomas Cubitt devised his plan. Meanwhile the Poor Law Commissioners had been at work. On the 14th of May of the same year appeared the Reports[9] of Drs. Arnott and Phillip Kay, "On the prevalence of certain physical causes of fever in the metropolis, which might be removed by proper sanitary measures;" and of Dr. Southwood Smith, "On some of the physical causes of sickness and mortality to which the poor are peculiarly exposed, and which are capable of removal by sanitary regulations, exemplified in the present condition of the Bethnal-green and Whitechapel districts, as ascertained on a personal inspection," which led to the inquiry, instituted in 1839, respecting the sanitary condition of our labouring population, and the production, in 1842, of the local reports, and the general one, by Mr. Edwin Chadwick, from the Poor Law Board to Sir James Graham. We pass over the continued inquiries respecting the state of the Thames. In 1844, the Commission for inquiring into the state of Large Towns and Populous Districts, was instituted. Their first Report appeared in June that year, and the second in February, 1845; then followed the consideration of the plans for the application of the sewage of the metropolis to agricultural purposes, and of the schemes proposed by Messrs. Wicksteed and Higgs—by the Select Committee of 1846—the further inquiry into the special means requisite for the improvement of the health of the metropolis—the rapid succession of the Reports of this Board in 1847-8, and the passing of the "Public Health Act, 1848," August 31st—the consequent appointment of the General Board of Health—of a first Metropolitan Commission of Sewers, and of their Ordnance Survey Committee—of a second Metropolitan (and a City) Commission of Sewers—their consideration of proposed schemes—their appointment, on the 15th of December last, of a sub-committee to report thereon—and finally, the communication of the Report, at their special general court, March 15th, 1850. Such is only a brief and imperfect retrospect of the chief events connected with the desired improvement of the health of the metropolis during the 30 years' peace. The result of all this labour is not of the satisfactory kind we should wish to have to record. We are told by the sub-committee, consisting of Sir John Burgoyne, Capt. Vetch, and Messrs. Harness, Rendel, and Stephenson, that "they have carefully examined and considered the whole of the plans and suggestions submitted to the Commissioners for the drainage of the metropolis;" that "though they do not deem themselves justified in recommending any one of these schemes for adoption, as a whole, they yet think that one," out of 116 plans for drainage, and 21 miscellaneous suggestions, "contains many of the main elements of a sound and practical system of drainage;" but that a portion of this scheme "involves great difficulties," and that they "consider it decidedly bad and objectionable." The remaining 115 are all deemed less or more faulty or unavailable.

This conclusion we fully expected. We observed at the beginning of this paper that the delay which has taken place is not to be attributed to want of talent or exertion on the part of the persons concerned in the inquiries, but to the want of necessary *data* on which to build a well-founded proposal. Of the data required for this purpose there are two distinct kinds, viz.:—Data derived from local circumstances, indispensable in framing a plan; and data connected with details of construction necessary for carrying into effect a proposed scheme: our want of the latter kind of data we have already endeavoured to illustrate; with regard to the first kind the Committee express themselves to the following effect:—"It is probable, that were we now called upon to deal with the drainage of London, as an original question, and wholly without reference to previous proceedings, we might reflect that a well-conceived and maturely-digested plan of general drainage could not be framed without a larger stock of local information of an accurate and specific character than could be collected by the unaided efforts of individuals, or made accessible to them without undue expense and inconvenience. The effect of this deficiency of the necessary information has become apparent in several of the schemes submitted to us, which, though well conceived, so far as regards their general features, are wholly inconsistent with the levels and other natural conditions of the localities to which they are intended to apply;" and Mr. Sheriff Lawrence, in his address to the Board, after the reading of the Report, adds, "Many whose plans were exceedingly good, had commenced them and prepared them without having sufficient *data* to go upon, and had been unable to fulfil their intentions in the manner which he was quite sure they would have done if they had had proper *data* to go upon. That, however, was no fault of the Commissioners, because *they were not themselves furnished with the materials to furnish such data;* but at any rate, there had been no favouritism in the decision given." Doubtless, as the decision shows. The want of the first kind of data is now admitted—*later*, we shall have to acknowledge the want of the second kind.

Accordingly, we find that few engineers of repute—those who have devoted their special attention to this one subject for the last few years, of course, excepted—have sent in plans. We look in vain in the list of competitors for the names of our principal R.E.'s or M. Inst. C.E.'s; and we cannot be astonished at the conclusion arrived at respecting the merits of the majority of the schemes. How so many persons can have thought proper to venture to send in plans under the circumstances described, is to us a mystery. Many, we fear, embraced the popular opinion that the drainage of London was wholly a question of outlet, and that that once found, the necessary details of a comprehensive scheme must naturally follow. The late outcry for an outfall, was, and is still, for the present, a mere fallacy; which simply reminds us of Archimedes asking for a prop, as the only condition necessary to enable him to lift the world—with this difference, however, that, like the Egyptian astronomer who, while calculating the motions of the planets, fell into a hog in his own garden, we can analyse accurately the impossible case proposed by Archimedes, but are perfectly helpless as regards the other, which nevertheless necessitates an immediate decision. We have the sewage of a vast population to get rid of some how: one person offers to treat it chymically; another proposes to empty it into the Thames; a third is of opinion it should be carried off under the bed of the river; and a fourth maintains that, on the contrary, it ought to be raised by steam. What with one person wishing to collect it in tanks, and another to drown it, a third to sink it, and a fourth to raise it—what with dry manure, and highly-diluted ditto, sinking shafts and erecting engines—we have now such conflicting opinions on all points, that we are even beginning to question the truth of the very premises we started with; and the only conclusions respecting which there can be said to be a general agreement of opinion, are—

1. That the present provisions for the drainage of London are insufficient, and in themselves defective.
2. That the thorough drainage of the metropolis is desirable, if it can possibly be attained.
3. That the pollution of the Thames with sewage is to be avoided, provided there be a possibility of effecting the necessary drainage without it, as outfall, within the limits advisable for all sanitary requirements.
4. That refuse-sewage has intrinsic value, which ought to be made available.
5. That a diversity of opinions exists respecting the details connected with town drainage.
6. That this diversity of opinions has prevented, hitherto, effective means being devised to remedy the evils to which a large body of this population is still subject.
7. That something ought to be done.

Let us now consider the question itself, and take a common-sense view of the case.

The premises we start with are the four first of the above conclusions. We send for an engineer. We request him to undertake to remedy the evils we complain of. What is his first step? His first step is to ask for "instructions" respecting all such points as are not within *his* control, and which must in any way influence his decision: "Your water supply is defective? What are the intentions of the legislature as regards its improvement? Will the supply be limited or constant? If the first, to what extent? Can you provide me with a supply in certain districts, if required, and to what extent? Will the same provision be made throughout the metropolis; and if not, what will the respective provisions be for each district? &c. &c.—You wish to preserve the sewage for agricultural purposes? Will it be sufficient to have it conveyed to one point, say the Essex marshes; or do you require means of direct communication into the country by rail, in different directions? If so, to what extent and in what directions? In what state must the refuse be delivered? To what extent diluted? Will the whole of it be required, or only a part, during one portion of the year; and if the latter, to what probable extent? &c. &c.—

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[8] Second Report of the Metropolis Improvements (1838), p. 149.

[9] Fourth Annual Report of the Poor Law Commissioners. App. A. No. 1.

Are you prepared to answer these questions?—if not, and you request me to come to my own conclusions respecting these preliminary points, I must put off the main one of an effective drainage, until I have instituted the necesary inquiries in connection with some of them; and obtained the further information, over which I have no control, respecting the remainder."—His next step is to obtain the required local data, which would be comprised principally in — 1st, an accurate trigonometrical survey of the whole area at all likely to be necessary for a full investigation; plotted, first, to a sufficiently large working scale for all matters of detail, say five feet to the mile; and, secondly, to a smaller scale of perhaps eight inches to the mile. 2ndly, a net-work of levels plotted on both plans, in contours at vertical equi-distances, say of two feet; with, on the larger plotting, a second, and may be a third, set of secondary contours, equi-multiples of the first, on all such portions necessitating the same, on account of the lowness of districts or other cause. 3rdly, a skeleton plan of the present drainage works, the levels of the underground portions of which would be embodied chiefly in, 4thly, a set of longitudinal sections, reduced to the same datum as the contours, of all the present main and branch sewers and drains. And, 5thly, other local information of different kinds, respecting the nature of which it is not necessary for us here to dwell. Are we prepared to furnish these? —If not, we must give up all thoughts of a "comprehensive" scheme, *truly capable of being found efficient in practice*, until we have obtained them.

Admitting these requirements obtained, an engineer would still have a great number of difficulties to contend with, for the reasons stated at the beginning of this paper; and the result of his labour would probably be the production of two or three schemes, varying in principles—each with advantages and disadvantages, of which it would be his duty to point out the nature. For instance, one plan might embody a comprehensive scheme, depending upon natural resources as far as possibly available, with many of the consequent advantages of a natural system of drainage, but defective in as much that these natural resources are not available in certain low districts without flushing—itself an artificial means—and that a portion of the drainage would be intermittent. The next, on the contrary, might provide for the removal of the sewage by artificial power; it would have the advantages over the first scheme, of being constant and thoroughly effective throughout—its defects would lie in the adoption of purely mechanical means and extensive machinery, instead of merely the natural power afforded by gravitation. The third would probably be a combination of the principles of the two first, according to local circumstances of level, including only the minimum amount of artificial power consistent with a constant and truly efficient discharge of the refuse. This last would probably be recommended.

Had these steps been followed more strictly, we should now be in a better position to report progress; but as it is, we are anything but prepared to frame a comprehensive plan. Moreover, we fear our progress, of late, has been like that of the crab—backward: we are beginning to doubt that the pollution of the Thames is an evil; and soon we shall be informed that the defective state of our drainage is in a great measure a fallacy, and that, with a few improvements—a main sewer here, and a brick drain there—we shall do very well indeed. This, however, is not the greatest evil we have to dread; we have to fear the endeavour, by the waste of hundreds of thousands, to force the river Thames to do—by what we are pleased to term "natural means"—what, in spite of Mr. Sheriff Lawrence's opinion, she never was intended to do. The extraordinary accumulation of population on the river bank of Middlesex is a purely accidental circumstance, perfectly independent of nature, her laws, or her provisions; and the business of engineering is to *adapt* the resources she has so bountifully placed at our command for our well-being and happiness, and not to force upon her what she never provided for, when fortuitous circumstances of man's own creating render her provisions inadequate to his demands.

East Indian Railways.—Amongst the passengers for India by the steamer of the 20th ult., was Mr. George Turnbull, the resident engineer of the East Indian Railway Company, and his staff. A vigorous prosecution of the works is now looked for. From the recent reports of the Company, it appears that more than 300,000*l.* of the capital is already paid-up, upon which the guaranteed interest of 5 per cent. is accruing, and that arrangements have been made with the India House, by which, at the expiration of the current year, the paid up capital will amount to about 500,000*l.*, or one-half of the million required for the first section of the line.

INSTITUTION OF CIVIL ENGINEERS.

Feb. 26.—William Cubitt, Esq., President, in the Chair.

The paper read was "*On the Street Paving of the Metropolis, with an Account of a peculiar system adopted at the London and North-Western Railway Station, Euston-square.*" By Mr. William Taylor.

The paper commenced by directing attention to the importance of a good system of paving, in conjunction with a more perfect plan of sewage for all large towns. The paving of the metropolis has too long been carried on under an antiquated and unscientific system, of using large masses of granite, placed upon an inefficient substratum; the consequences of this were great noise, an imperfect foot-hold for the horses, danger of the constant fracture of the springs and axles from the jolting over an uneven surface, and great expence of repairs. The macadamised streets were manifest improvements on such a system, but the surface was not found capable of resisting the heavy traffic of the main thoroughfares of the City. The defects of the wood pavement so greatly exceeded the merits that it had been nearly abandoned.

Impressed with the disadvantages of the present system of paving, Mr. Taylor tried an experiment about ten years ago, by covering a surface subject to very heavy traffic, and subsequently, about five years since, entirely paving the departure side of the Euston Station of the London and North-Western Railway in a peculiar manner. The system was upon entirely new principles. The method employed was, after removing the subsoil to the depth of sixteen inches, to lay a thickness of four inches of strong gravel, equally and well rammed, then another layer of gravel mixed with a small quantity of chalk, or hoggin, for the purpose of giving elasticity, the ramming being continued as before; a third coat of the same materials, was then laid and rammed, a regular degree of convexity of surface being preserved. The stones used were of Mount Sorrel granite, dressed and squared into regular masses of four inches deep, three inches thick, and four inches long: these stones were laid in a bed of fine sand, one inch in thickness, equally spread over the surface of the substratum, and they were carefully placed, so that no stone should rock in its bed. The whole surface was then well driven down with wooden rammers, weighing fifty-five pounds each. The small size of the stones enabled them to be well rammed home, so that the surface of the pavement never sunk, and the hardness and toughness of the material, prevented the stones from being worn down by any traffic, however heavy.

It was stated, that this system was found infinitely preferable to the employment of large stones, and the statement of cost was vastly in its favour; the price of the ordinary kind of granite paving, in London, being eighteen shillings per superficial yard, and the maximum cost of the new or "Euston" pavement, including the substratum, was not twelve shillings per yard, and deducting the value of the old stones, not (in this latter case,) claimed by the contractor, the nett cost would only be nine shillings per yard.

The system was stated to have been very extensively employed at Birmingham, and many provincial towns, and it appeared admitted, that the beauty of the pavement when completed, was only equalled by its extreme durability, and by the manifest advantages it offered in its noiselessness, good foot-hold for horses, freedom from jolting, and the small repairs it required.

It was suggested, that the different Paving Boards should make a trial in streets of small traffic, by lifting the large stones, and cutting them into small cubes, or rectangular pieces, of three inches in depth, for the future pavement; so that a good field would be afforded for the practice of the paviours, which would enable them to be better qualified for the task of extending the system to the more important thoroughfares: by this means, too, a large surplus of stone would be accumulated for paving, and the refuse would be valuable for macadamising the roads in the outskirts.

March 5.—In discussing the merits of Mr. Taylor's system, it was contended that a rigid and unyielding substratum had been tried by Mr. Telford many years since, and had been used with success in some parts of the City paving, up to the present time. The average duration of the pavement on the streets in the City was stated to be eighty years, but that it was constantly subject to injury, from being moved by the water and gas companies. The pavement on London Bridge by Sir John Rennie was instanced as a good, but expensive, example of the use of long narrow stones; and that by Mr. Walker, on Blackfriars Bridge, was quoted as another instance of the success that might be obtained by great care in the preparation of the substratum, which was of concrete, and the stones of the pavement being laid with more than ordinary skill and care. The results in both cases were eminently successful, but it was allowed that such an expensive system, however beautiful, was not applicable to the ordinary streets.

It was admitted, that, although the principal streets of the City and the main thoroughfares of the West and East ends were well attended to, yet it must be allowed, that the paving of the majority of the streets was not in a satisfactory state, and it was attributed, in a great degree, to the want of a definite system being adopted; there being too many authorities in the shape of parish paving boards, each of which had a separate surveyor, too often equally inefficient and ill-paid. The water and gas companies appeared to vie with each other in their endeavours to destroy the paving; and a portion of the Strand was quoted as having been removed thirty times within two years.

With respect to Mr. Taylor's system of paving, it was contended, that the Mount Sorrel granite was a very superior material, both as regarded its toughness and durability, and that its natural structure enabled it to be worked very advantageously into the small cubes. The main feature of the system was the selection of the material for the substratum, and the careful preparation, so as to afford a sufficiently rigid, but yet imperceptibly elastic bed, whereon the small cube stones should rest. These stones being well driven down by repeated blows of light rammers, attained a degree of solidity which defied the heaviest traffic; and in the towns where the system was employed, considerable economy had resulted. The surface of the paving approached as nearly as possible to that of a macadamised road, affording even a safer foothold to the horses, and with less noise of passing vehicles. The surface possessed extraordinary durability, and it might be considered as a solid mass of granite. It was announced that within a few weeks there would be specimens of Mr. Taylor's system of paving laid down at the entrances of Hyde Park, where they would be subjected to regular traffic of a destructive nature, and which would be under constant observation.

A model of an improved Crossing Point was exhibited by Mr. Duncan, of Leeds; the notch in the rail was shown to be done away with, and the two rails in it were so dovetailed together, as to render any vertical motion between them impossible, thus materially strengthening the crossing.

A piece of brickwork, set in Greave's blue lias lime, and which had been kept under water for nine days, was also exhibited. This material was composed of one-third of lime to two-thirds of burnt clay; and it was stated to have been used with great success in the tunnels on the Great Northern Railway, as well as in many hydraulic works, in which it was as durable as cement.

March 12.—The paper read was, "*On Tubular Girder Bridges.*" By Mr. W. Fairbairn, M. Inst. C.E.

The author commenced by stating, that the chief points to be taken into consideration were:—First, the application of a given formula, for computing their strength; second, the excess of strength that should be given, over the greatest load that could be brought upon the bridge; and, third, the effects of impact, with the best mode of testing the strength, and proving the security of the bridge.

In the first place, it had been determined by experiments, that, in order to balance the two resisting forces of tension and compression, in a wrought-iron tubular girder, having a cellular top, the sectional area of the bottom should be to the sectional area of the top, as eleven to twelve; and that until this proportion existed, the usual formula could not be applied; this formula was, that the breaking weight was equal to the total area, multiplied into the depth, and into a constant (80), and divided by the length of the girder $\left(w = \frac{adc}{l}\right)$.

Considering the particular case of the Torksey bridge, the mean sectional areas of the top and the bottom, being respectively 51·08 square inches and 54·93 square inches, the latter was in excess of strength over the former, so that a reduction of the area of the bottom from 54·93 to 46·76 square inches might have been made with propriety, and would have been in conformity with the formula. By calculation, the ultimate strength of the bridge was found to be 1,152 tons, whilst the greatest total load, including the weight of the girders, &c., was only 372 tons; this gave a strength, greater than the heaviest rolling load that could be brought on the bridge, in the proportion of nearly five to one. Although, therefore, the proportion of the girders was not exactly that which the author recommended, he considered that "they were, nevertheless, sufficient to render the bridge perfectly secure." This conclusion was arrived at without taking into consideration, the amount of additional strength derived from the continuity of the girders, across the central pier. The exact proportions recommended were given in two tables extending respectively to spans of 150 feet, and of 300 feet. The depths of the girders of the first class were taken at one-thirteenth of the span, and those of the second class at one-fifteenth of the span. The author then investigated the effects of impact at different velocities. It did not appear that experiment established the fact of increased deflection at high velocities for in several experiments on a large scale, he had found the deflection as nearly as possible the same at all velocities. He concluded by recommending that the tests to be applied should never exceed the greatest load the bridge, was intended to bear.

Remarks.—In the opening of the discussion by Mr. Fowler, Mr. Bidder and Mr. Eaton Hodgkinson, it was remarked, that satisfactory as it was to have the confirmation of Mr. Fairbairn's authority, for the perfect safety of the bridge for all purposes of traffic, it would have been desirable, that he should have extended his calculations a little further, into the question of the increased strength derived from the continuity of the girder, across the central pier, which augmented the total strength fully one-fourth. It was also argued, that the excessive proportion of the bottom of the girder, although not an economical disposition of material, was in itself an important addition to the strength of the girder.

The definite proportions assigned in the paper for girders were disputed, and the attempt to assign empirical rules for the practice of engineers, in structures of this novel character, was earnestly deprecated.

It was important also to remember, that the large proportion of the bottom of the beam brought into action a corresponding quantity of the upper part of the side plates, in aid of the top. Thus it appeared, that if the subject had been pursued further, the proportion of five to one, by which the proportional strength of the beam, over the rolling load, was represented, would have been, from various causes, materially increased.

March 19.—The subject of Mr. Fairbairn's paper was resumed. Messrs. Wild, Pole, Rennie, Scott Russell, Eaton Hodgkinson, Walker, Glynn, Bidder, Professor Willis, General Pasley, and Captain Simmons, R.E., examined the question at great length, and under all views, illustrating their position by diagrams and models, used in the experiments and in the mathematical investigation.

It was stated, that after the remarks made at the last meeting, it was merely requisite to describe the experiments alluded to, and before doing so, to briefly describe their object.

In the Report of the Government Inspector, the limiting strain required for the public safety was defined, and the Torksey bridge had been condemned for not complying with those conditions. A calculation, therefore, had been made to ascertain the actual strain on the bridge. It appeared, however, that it was really *less* than the limit prescribed by the Government Inspector. The experiments instituted were for the purpose of testing these contrary results. It was also stated, that in the paper there were many objectionable points, but particularly one that was positively dangerous.

The author had not only omitted the effect of the continuity of the Torksey girders, but stated, that it was *safer* to do so. Now all writers upon the subject, and all who had considered the matter, agree that in a continuous beam the effect of continuity was most important, and that in a *perfectly* continuous beam, the strain over the supports was even greater than elsewhere. It was therefore submitted that this was not the part, the consideration of which it could be "safer to omit."

The form taken by a continuous beam, when uniformly loaded, was convex over the supports, and concave between the points at which the convexity ended; at these points of contrary flexure, the horizontal strains were null, and the beam might then be severed, without altering its condition. The virtual length of the beam, in the Torksey bridge, was determined by the distance between the exterior support and the point of contrary flexure; and it was to determine this point practically that the experiments were instituted. It was shown that this point was 21¾ feet from the centre support, and that hence the length of the beam was reduced from 130 feet to 108¼ feet.

The compressive strain upon a girder of this length, loaded as prescribed, was 4⅜ tons per inch, being less than the limit defined. Consequently, it was asserted, that the Railway Company to whom this bridge belonged, had been deprived of its use, not in consequence of any omission on the part of their engineer, but in consequence of the inability of the Government authorities to appreciate the strength that had been provided.

In reference to the application of formulæ to the calculation of the strength of the girders, it was considered desirable, in such an important case, not merely to form a general approximate notion of the strength of the bridge, but to ascertain, with all possible exactness, the nature and amount of the strains to which the structure was exposed; and this could only be done, by using a comprehensive process of calculation, which should embrace all the elements affecting the strength of the bridge.

The effect of the continuity of the girders over the two openings, was carefully considered, and the nature of its effect upon the strain was explained, as deduced from the application of the most modern mathematical investigations, and it was demonstrated that the strength of the beam was thereby augmented above one third.

It was then shown, how the rules for estimating the strength of elastic beams, were rendered applicable to the case of the Torksey bridge, and the results proved, that when the bridge was weighted with the load prescribed by the Government authorities as a test for its strength, the strains of compression and extension were only one half of what competent authorities had stated might be safely applied.

The diagrams exhibited, shewed the results of mathematical calculation, as applied to the Torksey bridge girders, and the remarkable coincidence of these, with experimental results obtained by other investigators in an entirely different manner, was insisted on, as a proof of the correctness of the conclusions arrived at.

It was stated, in reply to a remark upon the increased deflection due to velocity, that the result of the experiments tried by the "Cast-Iron Bridge Commission," proved, that "this increase was wholly insignificant in beams of the length and stiffness of those of the Torksey bridge."

The discussion was summed up by its being stated, that, with one exception, all those who had spoken during both evenings, agree that the formula given in the paper was empirical and not trustworthy; that the effects of percussion and increased velocity were practically only *shadowy visions*; and as it was admitted, that in the calculations of the Government Inspector, the effect of continuity was neglected, and as it had been proved that the strain was less on the bridge than that assigned as requisite *for the* public safety, and that it was, in fact, amply strong, it was evident, that the public had been wrongfully deprived of the use of the bridge, and the Company had been prohibited from gaining the just return for the *capital* invested, in consequence of an incomplete investigation, and the assumption of untenable formulæ.

ON ARTIFICIAL BREAKWATERS.

On Artificial Breakwaters, and the Principles which govern their Construction. By Mr. A. G. Findlay.—(Paper read at the Society of Arts, London.)

Mr. Findlay's paper commenced by stating, that it was not wished to pronounce upon the feasibility or impractibility of any of the numerous plans which have, from time to time, been proposed for the construction of breakwaters, but to submit some facts, drawn from natural effects, showing the forces to which such structures must be subjected.

The paper, therefore, was naturally divided into two parts. The first, which related to the action of the waves, and its collateral subjects; and the second, which was postponed for a future evening, will relate to the various forms which have been given to sea-barriers, and the history of the progress of those now in existence.

The principal difficulty in establishing a fixed breakwater was shown to be the enormous force of the waves. The form and nature of sea-waves generally were alluded to, and Mr. Scott Russell's system described. Of the dynamic force exerted by sea-waves, it was stated that their greatest force was at the crest of the wave before it breaks; and its power in raising itself was measured by a number of facts. At Warberg, in Norway, it rose 400 feet, January 21, 1820: on the coast of Cornwall it rose 300 feet in 1843. Other examples, as the singular "Souffleur" at the Mauritius, &c., were cited, showing that the waves have raised a column of water equivalent to a pressure of three to five tons per square foot; a result in accordance with Mr. T. Stevenson's observations with the Marine Dynamometer, which was described.

It was shown by a table that the velocity of waves was dependent on their length; that waves of 300 to 400 feet in length from crest to crest, travelled with a velocity of 20 to 27½ miles an hour, and this whether they were 5 or 54 feet in total height; this velocity alone, should they become primary waves of translation, would give them a great percussive force. That waves travel very great distances was instanced by several facts. That they are raised by distant hurricanes and gales was noticed, by their being felt simultaneously at St. Helena and Ascension, though 600 miles apart; and opinions quoted, that these rollers, or ground-swell, at times originated near Cape Horn, 3,000 miles distant; rendering it more than probable that tropical hurricanes will send storm-waves to our own shores.

That it was not only at their surface that waves exerted great power, but that they reach in their action to the depth of eight fathoms and upwards, was shown by the operations for the recovery of the treasure of H.M.S. *Thetis*, which was wrecked and sunk at Cape Frio, Brazil, in 1831. The diving-bell was swung four or five feet laterally in calm weather in these operations, much increasing their danger. Besides this, the guns and treasure were found covered by masses of rock of from thirty to fifty tons weight, moved by the action of the water, and weighed or turned over in the second operations by Captain De Roos.

From these facts, it was considered that floating breakwaters generally were not adapted to combat with the waves. Admiral Taylor's plan of timber frame-work sections; Captain Grove's iron cylinders with an attached grating; Captain Pringle's frame, moored by its lower edge; Captain A. Sleigh's floating sea-barrier; Mr. Smith's plan, as submitted to the Society, were mentioned; and it was considered that the calculations of their resistance were understated; that Admiral Taylor's section, instead of twenty-five tons' strain, might, if the waves exerted only one-third of their force as known, have to withstand upwards of 1,000 tons; this probably caused the failure of Admiral Taylor's experiment at Brighton, and Captain Groves's at Dover. Major Parlby's principle of the trumpet-mouth sea-weed was compared with the *fucus giganteus* of Dr. Solander, abundant on the Patagonian and Fuegian coasts, and 360 feet in length, which is carried under water in currents, and torn up, and chokes all the bays during storms.

The motion of shingle, an important consideration in establishing breakwaters, was shown to be governed by the direction in which the surf strikes the shore, and this is dependent on the direction of the wind. This, from fifteen years' observations by M. Nell de Bréauté, at Dieppe, was shown to be in the ratio of 229 days from western quarters to 132 days from eastern quarters, giving that preponderance to its eastward progress. The mode in which it was arranged on the sloping beach, in the form of a paraboloidal curve, was explained.

Sand, a more powerful agent than shingle in changing the character of a coast, was stated to be deposited by currents, thus rendering the eastern parts of the English Channel much more embarrassed by them than the western portion. The Goodwin Sands were exhibited as examples of the extent of accumulation, and the changeable character of sand deposits. The diagrams exhibited showed the progress of these alterations, and were drawn from, perhaps, the only authentic history we possess of the changeable character of a quicksand. The different periods, from Græme Spence's survey in 1795 down to Captain Bullock's in 1850, showed that they had shifted miles in their position and area, evidently refuting the practicability of any principle which would apply to fixing them, and rendering them available more perfectly for breakwater purposes, as was proposed by Captain Vetch, R.E., to the Royal Commission, 1845.

Mr. Finlay commenced the second part of his paper by recapitulating some of the forces and circumstances to which breakwaters are subjected, as cited in the former abstract. The application of these was the subject of the present portion.

The preparations for the great Cherbourg *digue* were noticed; the proposals of 1712, and 1777, for a line of sunken ships filled with masonry, as at the siege of La Rochelle in 1573, and the first operations by M. de Cessart, in 1782-4, were described. This latter plan was to sink truncated conical caissons, strongly framed of timber, 150 feet diameter, and 64 feet high, floated by means of a double tier of immense casks around their bases. The first and second was successfully launched; but before the latter could be filled with stones, as intended, a storm carried it away to low-water mark. This led to a great change in the plan; instead of 90 of these cones tangent to each other, they were to be placed at considerable distances apart, the intervals to be filled with *pierre perdû*; 18 of them were laid, but they were all destroyed but one before 1789,—some of them in two days after their being placed. The method *à pierre perdû* was then resorted to, and continued with until it was modified by an upright parapet from low-water level by M. Dupare, 1832; the work is still in progress.

The series of four different slopes, in which the waves have distributed the stones of the *digue* was described; and the absence of the lowest slope in the Plymouth section was accounted for by the increased force of the waves upon the latter.

The commencement in 1811, by Mr. Rennie, and subsequent proceedings under its present superintendent, Mr. Stuart, of the Plymouth Breakwater, were then alluded to, and the increased length of foreshore which had been found necessary, from the original design, and the greater effect of the sea at its *west* end described. In 1838, from the great effects of a storm, a species of buttress was designed by Mr. James Walker, C.E., for the protection of the base of the lighthouse. This involved a new principle in hydraulic architecture, afterwards alluded to.

This structure resembles in some degree the system of dovetailing and grooves adopted by Smeaton in the Eddystone; but differs in its application. The Delaware breakwater in the United States was then briefly alluded to.

The principle of the presenting a concave face to the waves was then adverted to. In 1734, such a section was proposed, but not acted on, by M. Touros, for S. Jean de Luz. In 1787-95, Don Tornas Munos constructed the sea-walls of Cadiz thus: a straight foreshore of timber planking, and a curved masonry termination. This was destroyed by the blocks of stone placed at its foot for protection, rolling up the incline against the masonry. M. Emy, who endeavoured to establish the existence of what he denominates the *flôt-du-fond*, proposed a cylindrical, or other curvilinear face, for this purpose, in 1818, and in 1820 repaired the works of the fortification of St. Martin, Ile de Re, in the Bay of Biscay, on his plan, which was so far successful, though not very greatly exposed. Various forms of the concave *rèvetement* were noticed, and the natural form assumed by the shingle beach was cited as an instance of the effect of beach surf. This form has been adopted in the Dymchurch wall, constructed by Mr. Walker. The mode of action of the waves against a cliff was also explained, as producing a similar action.

Mr. Scott Russell's deduction from the wave system, leading also to similar conclusions, were then alluded to, and the sectional form he has proposed described. He preferred a paraboloidal curve for the foreshore; and an overhanging coping, so as to turn the wave on itself, was described. Mr. Russell, for deep water structures, preferred the method *à pierre perdû*, forming a straight foreshore. One objection to this system of concave face was, the varying level to which such structures are exposed by tidal influences, and the differences of curve presented at different periods of tide.

From these systems, the vertical, or nearly vertical wall, was then described; and the great national work at Dover, the Refuge Harbour, was stated to be on the principle established by the experience of the buttress at the west end of Plymouth breakwater. This mode of construction, found effective at that place, counteracts some of the difficulty met with in securing the masonry facing it. In a previous part of the paper it was stated that the stones were blown out of the facing, or towards the sea wave. This action is attributed to the percussive force entering the joints, and thus the water or air contained within the body of the masonry being most forcibly driven upwards and outwards, carried single stones out of their beds. The new mode consists of stepping one course of stones into the upper surface of that beneath it, so as to form a ledge to prevent its outward tendency, and also to divert the direct action of the wave on the joint. In addition to this, each stone is so dovetailed on its horizontal plane, that each course forms virtually one stone; and alternate stones in each course are locked into the course beneath it; so that, throughout the fabric, some portion of each course belongs to the one on either side of it, making the whole into one mass. These stones are found at the quarries, and fixed in their places by the diving-bell. The situation of Dover Harbour, as being free from the chances of silting up, was considered in reference to the tides, and the improbability that any great amount of shingle would for the future embarass the work.

NOTES OF THE MONTH.

Professional Jurisdiction.—In the inquiry before Mr. Cubitt, as Admiralty Inspector, on the Lea Navigation Bill, the East London Water Works Company claimed to be heard by counsel; and on the 25th, on the opening of the court, Mr. Merewether appeared to support their application on the threat of withdrawing altogether from the inquiry. Mr. Cubitt adhered to the determination he had expressed by letter, of hearing only engineers or solicitors; and this refusal having been recorded in his minutes, Mr. Merewether left the room. We hope Mr. Cubitt, and other engineers, acting in the like official capacity, will be equally firm, for there can be no reason, before such a tribunal, for the employment of barristers, who have to be instructed by engineers. Solicitors, are persons practically acquainted with the business of their clients. There can be no hardship on the Waterworks Company, for they could have adequate engineering assistance. The Board of Ordnance, who opposed, were represented by their solicitor and two government engineers; and most of the other opponents by engineers or surveyors. As a startling example of the mischiefs of employing non-practical men, we may refer to the celebrated Reading case, where many days were lost by the several batches of counsel.

Opening for Traffic of the Britannia Bridge.—On Friday and Saturday, the 15th and 16th ult. Captain Simmons, the Government Inspector for the Railway Commissioners, made his official inspection of this great structure, accompanied by Mr. Edwin Clarke, the resident engineer, and Mr. Hedworth Lee, the engineering manager of the Chester and Holyhead line, when a series of important experiments took place to ascertain the law of deflection, and the absolute structural strength of the fabric. The experiments consisted in observing the deflections under a series of successive loads; the passing of three locomotives, with a train sufficient to cover each of the tubes, through the bridge, at various speeds, and the running of locomotives and tenders through, without trains, at variable rates of progress. The first experimental Government train was a heavily laden one of coal wagons, weighing 240 tons, with three locomotive engines. This was run through the tube at the ordinary rate at which such trains travel, from 10 to 12 miles an hour, and the deflection, as taken by deflectometer, fixed in the centre tower, was scarcely perceptible. This train was then drawn completely over one of the tubes, and there left as a dead weight, while Captain Simmons descended and made a minute inspection of the masonry, the rivetting, plate-work, cellular top and bottom of the tubes, and other arrangements, which occupied a considerable time. On returning to the tube, the deflection caused by the load was found to be about three-fourths of an inch. Similar experiments made in the other tubes exemplified the perfect success that has attended the continuity of the beam—the most remarkable feature in the structure, caused by the junction of each of the before isolated tubes, for as the engines entered upon the small land tube the motion due to their progressive weight was ascertainable in every tube, even over to the further extremity of 1560 feet in length. Locomotives in steam were then passed through as fast as practicable, but only at 20 miles an hour, owing to the curves at either end. The deflection was the fraction of an inch, and the vibration scarcely perceptible, the tonnage weight of the tube itself acting in reality as a counterpoise or preventive to vibration. On the Monday following, the up express from Holyhead, carrying the mails and passengers from Ireland, came by the tube at a saving of a full hour over the usual transit. The subsequent trains to and fro also went through both ways. All the arrangements for this purpose are now permanently complete, and the floating of the twin tubes for the parallel line is occupying the attention of the engineers.

Improved Covering for Railway Wagons, to supersede the cumbersome and loose tarpaulin, has been patented by Mr. Rowland Brotherhood, of Chippenham. It allows of a small or large portion, or the whole area of the truck, to be exposed; one porter can uncover two trucks in the space of a minute, and two can re-cover them in the same time. It consists of a fan of seven ribs, placed at each end of the truck, connected in pairs by a horizontal bar to each over the top of the truck; this fan is covered with prepared water-proof canvas, and is opened and inclosed with as much facility as the head of a cabriolet or landau, on which principle it is constructed. It affords great facility for loading and unloading goods; can be secured by locks and keys. It has been in use all the winter on the Great Western line with much satisfaction.

Improved Manufacture of Peat Charcoal.—Although numerous have been the attempts to produce a charcoal from peat, fit for all, even the most delicate metallurgical purposes, and although several patents have been obtained within the past few years for particular methods of manipulation, success has not yet appeared to have crowned our efforts in this country. While these attempts have been made in vain in England and Ireland during the past ten years, Mr. Vignoles, the well-known railway engineer, during his professional duties on the continent, discovered that a process for converting peat into charcoal or coke, had been most successfully carried out in Germany for some years past. He accordingly availed himself of the opportunity, and having made himself master of all the details of the process, has taken out a patent for Ireland, from the specification of which we extract the following particulars:—The peat is subjected to a certain high temperature, in such manner as to deprive it of the whole, or a principal portion, of the water which it naturally contains. This heat is then continued under peculiar circumstances until the peat is converted into charcoal or coke. One of the most important properties of the process is, that by the mode adopted of applying the heat the substance is not burned to ashes and wasted. In the first part of the process, the peat or turf extracted from the bog by any of the usual methods, is dried in pieces of any convenient size, either by exposure to sun and air, or to artificial heat, and afterwards placed in an iron vessel of large capacity, called the "carbonising vessel." Steam, generated in any form of boiler, with a pressure of from 45 lb. to 60 lb. per square inch or upwards above the atmospheric pressure, is passed through a number of tubes of iron, heated to a bright red heat, by being placed in a suitable furnace, so that without losing its pressure it acquires additional temperature up to 450° or 460 Fahr., or about the melting point of tin or lead. This part of the apparatus is called the "coil," the surface of which should be nicely proportioned to the generating power of the boiler. The steam thus highly heated is permitted to pass into the "carbonising vessel" containing the partially dried peat, and the effect is rapidly to withdraw any moisture which may remain, in the state of steam, from the peat; the whole of the steam from this vessel is allowed to escape, and may be advantageously used as a motive-power, for preparatory desiccation of the turf, or for any other purpose. After this drying process has gone on until the peat or turf has parted with nearly all its moisture, it begins to be charred or carbonised by the high-pressure steam, and in proportion as the dehydration of the peat advances, so does the temperature of the carbonising vessel increase, until it approaches closely to that of the steam in the coil, which must be sufficiently high for the perfect decarbonisation of the peat. The process is continued until the turf is found reduced to a black substance, retaining the forms nearly of the original masses, but now almost a perfect vegetable charcoal or coke.

Dr. Potts.—Dr. Lawrence Holker Potts died on the 23d of March, at the age of 60. He was the patentee of the system of hydraulic piledriving, which is applied on the Chester and Holyhead, Windsor, Great Northern, and other railways. He was likewise the inventor of a process for preserving animal substances. His mechanical genius showed itself even when a boy at Westminster school, in constructing an electrical apparatus from a quart bottle, and like rude materials; and as it afterwards influenced his professional pursuits, having distinguished himself very much in the application of mechanical contrivances to the treatment of spinal diseases. Dr. Potts was a native of London, but practised long at Bodmin; and was the founder of the Royal Cornwall Polytechnic Society.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM FEBRUARY 23, TO MARCH 20, 1850.

Six Months allowed for Enrolment, unless otherwise expressed.

Charles Andrew, of Compstall-bridge, Chester, manufacturer, and Richard Markland of the same place, manager, for certain improvements in the method of, and in the machinery or apparatus for, preparing warps for weaving.—Sealed February 21.

James Hall, of Geecross, near Stockport, Chester, machine maker, for certain improvements in looms for weaving.—February 25.

Brereton Todd, of the Bank, Falmouth, gentleman, for improvements in the manufacture of arsenic, sulphuric acid, and the oxide of antimony, from copper and other ores, in which they are contained, and also the oxide of zinc.—February 27.

George Gwynne, of Sussex-square, Middlesex, esquire, for improvements in the manufacture of sugar.—February 27.

Matthew Cochran, of High-street, Paisley, Renfrew, North Britain, manufacturer, for improvements in machinery for the production and ornamenting of fabrics and tissues generally, parts of which are applicable to the regulation of other machinery, and to purposes of a similar nature.—February 27.

Julius Jeffreys, of Bucklersbury, City of London, gentleman, for improvements in preventing or removing affections of the chest.—February 28.

George Tosco Peppe, of Great Marylebone-street, Middlesex, civil engineer, for improvements in time-keepers.—February 28th.

George William Lenox, of Billiter-square, City of London, chain cable manufacturer, and William Roberts, foreman to Messrs. Brown, Lenox, and Co., of Millwall, for improvements in working windlasses and other barrels—February 28.

Thomas Richards, William Taylor, and James Wylde, the younger, all of Falcon Works, Walworth, Surrey; cotton manufacturers, for improved rollers to be used in the manufacture of silk, cotton, woollen, and other fabrics.—March 2.

William Edwards Staite, of Throgmorton-street, City of London, gentleman. for improvements in pipes for smoking, and in the apparatus connected therewith.—March 4.

William Mac Naught, of Rochdale, Lancaster, engineer, for certain improvements in steam-engines; and also in apparatus for ascertaining and registering the power of the same.—March 7.

John Fowler, jun., of Melksham, Wilts, engineer, for improvements in draining land.—March 7.

William Benson Stones, of Golden-square, Middlesex, Manchester warehouseman, for improvements in treating peat, and other carbonaceous and liqueous matters, so as to obtain products therefrom. (A communication.)—March 7.

Henry James Tarling, of Bayswater, Middlesex, commission agent, for improvements in the manufacture of fuel and manure, and deodorising and disinfecting materials.—March 7.

William Brown, of Airdrie, Lanarkshire, electrician, and William Williams, the younger, of St. Dennis, Cornwall, gentleman, for improvements in electric and magnetic apparatus for indicating and communicating intelligence.—March 7.

Ebenezer G. Pomeroy, of Cincinnati, Ohio, United States, chemist, for a new and useful process of coating iron, and other metals, with copper and other metallic substances.—March 7.

William Church, of Birmingham, engineer, for certain improvements in machinery or apparatus to be employed in manufacturing cards, and other articles, composed wholly or in part of paper or pasteboard; part or parts of the said machinery being applicable to printing the same; and other purposes where pressure is required.—March 7.

Richard Archibald Brooman, of the firm of Messrs. J. C. Robertson and Co., of Fleet-street, for improvements in types, stereotype plates, and other figured surfaces for printing from. (A communication.)—March 7.

Richard Carte, of Southampton-street, Strand, Middlesex, professor of music, for certain improvements in the musical instruments designated flutes, clarionets, hautboys, and bassoons.—March 7.

John Taylor, of Manchester, mechanical designer, and Richard Hurst, of Rochdale, cotton spinner, for certain improvements in, and applicable to, looms for weaving, and in machinery or apparatus for preparing, balling, and winding warps or yarns.—March 7.

Gerard John de Witte, of Brook-street, Westminster, Middlesex, gentleman, for improvements in machinery, apparatus, metallic, and other substances, for the purposes of letter-press and other printing. (A communication.)—March 7.

John Tebay, of Hackney, Middlesex, civil engineer, for an improved meter, for registering the flow of water and other fluids.—March 7.

Frederick Rosenberg, of Albemarle-street, Middlesex, esquire, and Conrad Montgomery, of the Army and Navy Club, Saint James's-square, in the same county, esquire, for improvements in sawing, cutting, boring, and shaping wood.—March 7.

Thomas Irvine Hill, of Clapham, Surrey, gentleman, for certain improvements in the treatment of copper and other ores, and obtaining products therefrom.—March 9.

Richard Holdsworth, of the firm of Holdsworth and Co., cotton spinner, and William Holgate, engineer, for improvements in apparatus and machinery for warping worsted, cotton, and other fibrous materials.—March 11.

William Crane Wilkins, of Long Acre, Middlesex, engineer, for certain improvements in ventilating, lighting, and heating in lamps and candlesticks; in the manufacture of candles; and in the apparatus to be used for such purposes.—March 11.

James Nasmyth, of Lille, France, engineer, for improvements in the method of obtaining and applying heat.—March 12.

Robert Milligan, of Harden, near Bingley, York, manufacturer, for an improved mode of treating certain floated warp or weft, or both, for the purpose of producing ornamental fabrics.—March 18.

George Jenkins, of Nassau-street, Soho, Middlesex, gentleman, for certain improvements in the means of producing motive power.—March 18.

Thomas Edmondson, of Salford, Lancaster, printer, for improvements in the manufacture of railway and other tickets; and in machinery or apparatus for marking railway and other tickets.—March 19.

William Joseph Horsfall, and Thomas James, both of the Mersey Steel and Iron Works, Toxteth Park, Liverpool, Lancaster, for improvements in the rolling of iron, and other metals.—March 19.

Samuel Cunliffe Lister, of Manningham, near Bradford, York, and George Edmund Donisthorpe, of Leeds, in the same county, manufacturer, for improvements in preparing and combing wool and other fibrous materials.—March 20.

YORK COUNTY HOSPITAL.

Messrs. J. B. and W. Atkinson, of York, Architects.

(*With Two Engravings, Plates* V. *and* VI.)

We give herewith designs of the York County Hospital, now in progress, by Messrs. J. B. and W. Atkinson, of York, who are the architects of several public buildings in the county.

York is now the seat of a medical school which, under the modern regulations, can give a complete medical education; and the County Hospital is recognised by the medical universities as an institution for practice, having accommodation for the required number of one hundred patients. The building is faced with the best pressed red bricks, and has a stone basement, stone dressings to the windows, and stone quoins. The total cost will be about 9000*l*.; and it is expected the hospital will be ready for occupation in the autumn of this year. The works have been pressed on, as the building is much wanted, and there was great delay in deciding upon the site.

The hospital is to be heated and ventilated throughout on Dr. Arnott's plan, and we presume lighted with gas. The ventilation of such buildings is of the greatest importance for the recovery of patients after operations, for when once hospital gangrene sets in it attacks many patients, and is got rid of with difficulty. In a well ventilated hospital fever cases can be treated in the ordinary wards without danger. We are glad therefore to see the attention given by Messrs. Atkinson to the sanitary arrangements. The bath accommodation is shown on the plans, and we presume that hot and cold water are supplied to each ward.

The washing establishment, it will be seen, occupies some space, including a washhouse, laundry, and drying closet. The importance of this is not seen at first; but the truth is, the expenditure for washing forms a considerable item of the whole yearly expenditure, as there is such extensive use of linen for bedding, patients' wear, and for dressings, besides the private washing of the officers and servants.

The usual appurtenances of a medical school are provided, and include a library, laboratory, museum, deadhouse, and post mortem room.

We presume that the establishment is so arranged that it can be yearly whitewashed, an operation which is found most beneficial in such institutions; and though entailing an expense, adding much to the sanitary security. This is now done by yearly contract in most of the best conducted hospitals.

By the introduction of lifts, great trouble is saved to the nurses, much of whose time is otherwise taken up in the supply of provisions from the kitchens for the patients' meals, while there is less temptations to idleness.

Altogether, the arrangements are such as are suitable for such an institution, and reflect great credit upon the architects.

The following particulars describe the accommodation on each floor.

Basement Plan.—11 feet clear, and arched over.

1	Washhouse	47 × 12
2	Laundry	23 × 21
3	Drying closet	23 × 9½
4	Maids' hall	23 × 21
5	Larders and stores	
6	Kitchen	30 × 19
7	Sculleries	30 × 9½
8	Heating and ventilating apparatus, &c.	22 × 16
9	Air chamber	
10	Lifts	
11	Stone staircases	
12	Laboratory	23 × 11
13	Museum	31 × 23
14	Porter's bedroom	
15	Wine cellar	
16	Dead house	
17	Post mortem	

Ground Plan.—14 ft. 6 in. clear height.

1	Entrance hall	
2	Vestibule	42 × 13½
3	Dispensary	19 × 16
4	Waiting patients	22 × 9½
5	Physicans' room	22 × 16
6	Surgeons' room	22 × 16
7	Dressing surgery	16 × 11
8	Pupils' room	16 × 10½
9	House surgeon	20 × 16
10	Ditto bedroom	16 × 12

Ground Plan (*Continued*).

11	Matron's parlour	16 × 11
12	Male staircase	11 wide
13	Female do.	
14	Male accident ward	23 × 34
15	Female do.	23 × 23
16	Private separation ward	18 × 12
17	Nurses	
18	Sculleries, &c.	
19	Boardroom and library	42 × 23
20	Secretary	16 × 12

Chamber Plan.—15 feet clear height.

1	Chapel	21 × 19
2	Wards	42 × 23
3	Day-rooms	22 × 16
4	Private wards	16 × 12
5	Sculleries	
6	Baths	
7	Nurses	
8	Stores	
9	Lifts	
10	Stone staircases	

Attic Plan.—15 feet clear height.

[We have not space in our Engraving to show the Attic plan. It is 15 feet high, and contains the following accommodation.]

1	Operation room	21 × 19
2	Wards after operations	21 × 9½
3	Foul wards	22 × 16
	Wards	
	Private wards	
	Nurses	
	Sculleries and baths	
	Matron's bedroom	
	Lifts	
	Stone staircases	

N.B.—There are servants' rooms partly in the roof.

LECTURES ON THE HISTORY OF ARCHITECTURE:

By Samuel Clegg, Jun., M.I.C.E., F.G.S.

Delivered at the College for General Practical Science, Putney, Surrey.

(President, His Grace the Duke of Buccleuch, K.G.)

Lecture V.—Etruria.—Foundation of Rome.

Though the architecture of the Greeks has never been excelled, nor perhaps even equalled, by any other people, it was limited to one style, and only existed in its highest perfection for a few centuries. In Italy, on the contrary, we may trace the history of art by its monuments, through every successive style and period, from the rude unhewn altar to the completion of St. Peter's at Rome. It is, however, to the ancient architecture of Italy I would at present direct your attention.

When the Umbrians, Pelasgians, and afterwards the Etruscans, settled in Italy, they found the country inhabited by a wild race, called the Siculi or Sikeli. These never amalgamated with their more civilised conquerors, but gradually retreated before them, until at last they passed over to the neighbouring island, to which they gave the name of Sicily. Here and there, rude Cyclopean walls may be seen, generally forming the foundation of other and more advanced styles of masonry, which are conjectured to have been the work of the Sikeli. On the Alban mount, and in its immediate neighbourhood, singular urns of pottery have been found, buried under a stratum of peperino, eighteen inches in depth. These urns are moulded into the form of rude huts, as if made of skins stretched on poles, no doubt imitations of the huts inhabited by some early race. They are cinerary urns, and contained ashes when discovered. Small rude pots and lamps were found with them. When we think that these urns were lying imbedded under a stratum formed by some now extinct volcano, it carries the mind back to a remote antiquity indeed.

Next in order follow the Pelasgic remains already noticed. The Pelasgians and Umbrians appear to have been contemporary, nor can their remains be distinguished. Then succeed a more interesting people, the Etruscans, who have left so many beautiful works of art to bear witness to their dominion.

The name by which the Etruscans always called themselves was Rasena. That by which they were known amongst the Greeks was Tyrseni, or Turrheni; but as the Umbrians and Pelasgians in Italy were also called Tyrrhenian, it has given rise to some confusion.

Authors differ greatly as to whence the Etruscans came, or how far their dominion actually extended. In fact, we only know enough of them to excite our curiosity, without much hope of ever having it satisfied. Notices of the Etruscans are only scattered here and there in the Latin writings, nor can these cursory remarks always be relied upon.

Micali says, "It is easy to understand how, during a period when the passion for war was all-absorbing, the proud and barbarous indifference of the Romans despised the knowledge of a rival people, with whom they had so long disputed pre-eminence and the empire of Italy." But there is little doubt that the Romans not only despised, but wantonly falsified and destroyed the records and monuments of Etruria; and this has hitherto been an irreparable evil, as the Etruscan language entirely differs from any now known, so that the inscriptions on the tombs are but a dumb treasure.

But who shall place a limit to the discoveries of this age of energy and enlightenment? And when we remember how short a time it is since Dr. William Young first discovered the key to the hieroglyphics, and that within the last few months some light has been thrown on the cuneiform character of Assyria, we need not despair of being enabled at some future time to decypher the few remaining records of Etruria.

Though some authors advocate a different opinion, there seems every reason to believe that the Etruscans were of Eastern origin. Their religious forms and ceremonies, their architecture and style of masonry, all seem to denote this. According to Micali, "The Tuscan name filled with its glory all the country from the Alps to the Sicilian straits;" but their empire must soon have been confined to Etruria Media, as between 900 and 1000, B. C., we find the names of Ænotrians, Volscians, Latins, and others, as separate states: whether tributary or not is uncertain.

Long after this, however, and long after the foundation of Rome, the Etruscans continued "lords of the sea;" for out of respect to their power, the one sea was called Tuscan, the other Adriatic, from their great city Adria. They sent out colonies even as far as the coast of Spain, where they founded Tarraco, now Tarragona; and thus keeping up intercourse with all the nations bordering on the Mediterranean, wealth flowed into their country, and art and science followed in the train of commerce.

Etruria Media, or Etruria Proper, comprehended what is now the duchies of Tuscany and Lucca, the Papal States north of the Tiber, and extended across from sea to sea. The government was eminently favourable to the rise of art. It was aristocratic and federal; divided into twelve districts, under the names of the twelve principal cities, Tarquinii, Veii, Falerii, Cære, Volsinii, Vetulonia, Rusellæ, Clusium, Arretium, Cortona, Perusia, and Volterræ. Each of these cities was ruled by a chief lucumo, or king. Lars Porsenna was called King of Clusium. Tarquinii was the capital city of the kingdom; and in this district was the seat of the great national council, Voltumna. Thus these cities were independent, though united, and naturally vied with each other in producing noble works of art. The firmness of the government also tended to the cultivation of the elegancies of life; for Etruria changed neither name, language, laws, nor religious forms during the whole period of its existence, retaining the latter even after its subjugation to Rome.

In the north of Etruria the higher mountains are of limestone, and the lower range of sandstone. The southern district is almost entirely volcanic tufa, lava, and scoriæ, with occasional basalt or limestone peaks, like Soracte, overtopping the lower volcanic hills. Consequently the masonry of north and south Etruria differs considerably. Owing to the greater difficulty of working the limestone and sandstone, the blocks were seldom cut to a size, though generally squared and laid in horizontal courses. In the south, where the stone was of a softer nature, and more easily worked, the masonry was beautifully regular. The Etruscans seldom, if ever, used cement, but relied entirely upon the bond of their work. In some instances layers of thin bricks or tiles were laid between the courses of stone. Rustic work was also frequently used by the Etruscans.

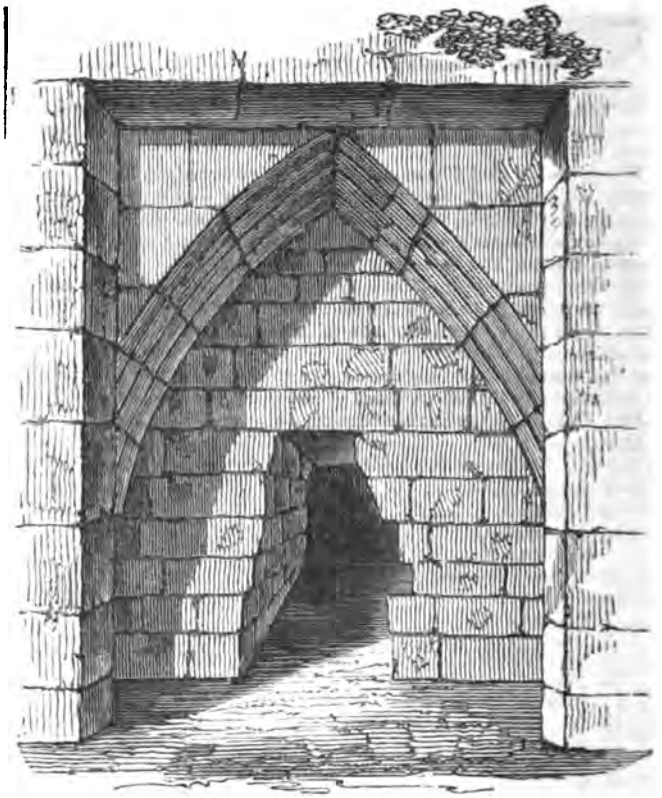
In part of the wall of Volterræ and elsewhere, the upper are much more massive than the lower courses, and are supposed to have been placed thus, that the larger stones might be opposed to the stroke of the battering ram.

The situation of Etruscan towns announces a greater degree of social security than was enjoyed by the Pelasgians or Umbrians. In the volcanic district the ground is split into ravines, each forming a sort of natural fosse. A piece of land lying between two such ravines was a favourite site with the Etruscans on which to erect their cities. In the north the towns were situated on an eminence, but not at such an unattainable height as the cities of the earlier settlers. Each city was surrounded by a massive wall, and guarded by square towers, usually about fifty feet apart.

Sir William Gell, in his description of the ancient Fescennium, says that about sixty towers yet remain standing. They have chambers in the upper story, with doors opening from them on to the wall, so as to allow of an uninterrupted passage along the ramparts. Each city had its citadel or arx, its temples, theatre, amphitheatre, baths, and other public buildings, remains of which may yet be traced. Each city had also a complete system of sewerage, by which the extent of these towns of ancient Etruria may be seen.

Etruria Proper was at one time so densely populated that there were walled towns, occupying many square miles, and containing several thousand inhabitants, within two miles of each other. Now, with few exceptions, these great cities are laid low. Perhaps a modern Italian village occupies a corner of the ancient site; but more frequently the spot is a wilderness, where the shepherds pasture their flocks, or a desolate swamp, where the demon malaria holds undisputed possession.

There is no doubt that the Etruscans introduced the principle of cuneiform sustentation into Italy. Whether they worked out the principle of the arch for themselves, or whether they acquired it from the Egyptians, it is impossible to say; but that they understood and practised it before the time of the Romans is quite certain.



Etruscan Emissarium.

It is singular that when they had once discovered this principle, they did not always practice it; but it seems they only applied it to great public works, and in other places still made use of the old Pelasgic methods. Many of their arches are formed by the courses of stone projecting one over the other; and in the emissarii, or grottoes at the embouchure of the water conduits, the pointed arch, constructed with flat stones meeting at an angle, is frequently met with. There is an uncemented arched cloaca at Graviscæ, the voussoirs of which are from five to six feet in depth; but the Porta all' Arco, at Volterræ, is considered the oldest and most perfect Etruscan archway now in existence. It has been a consecrated gateway, for the heads of the three divinities are placed above the imposts, and upon the keystone. It is generally believed to have been built 600 or 700, B. C.; but tradition gives it as early a date as 1186, B. C.

Porta all' Arco, at Volterræ.

Mr. Dennis, in his valuable work on Etruria (speaking of the Porta all' Arco), says "I envy the stranger his first impression on approaching this gateway: the loftiness of the arch; the boldness of its span; the massiveness of its blocks, dwarfing into insignificance the mediæval masonry by which it is surrounded; the venerable, yet solid, air of the whole; and, more than all, the dark, featureless, mysterious heads around it, stretching forwards as if eager to proclaim the tale of bygone races and events; even the site of the gate, on the very verge of the steep, with a glorious map of valley, river, plain, mountain, sea, headland, and island, unrolled beneath, make it one of the most imposing, yet singular, portals conceivable, and fix it indelibly on his memory."

It is a double gateway; the total depth about 27½ feet; the span of the arch is 13 ft. 2 in.; the height to the keystone, about 21½ feet. There is a groove for a portcullis; or, as the ancients called it, a *cataracta*, which was suspended by iron chains within the gate. Similar grooves or channels are found in all the old double gateways in Italy. According to Mr. Dennis there is a cinerary urn, found in the cemetery of ancient Volterræ, on which is figured Capaneus struck by lightning while scaling the gate of Thebes. The gate represented on the urn is an exact copy of the Porta all' Arco, with the three heads on the imposts and keystone.

The three principal divinities, Tina, Talna (or Jupiter and Juno), and Minerva were the only deities to whom temples were erected within the city walls. The ground plan of the temple was divided into six parts for the length, five being given to the width. The length was then divided into two equal parts, one of which was for the cellæ, and the other for the vestibule, or portico. The width was divided into ten parts; three parts on each side were given to the smaller cellæ, and four to the centre, or principal cella. These cellæ were sometimes separated by walls, sometimes only by columns, like a nave with side aisles. The principal altar was in the centre cella, answering to the high altar in Catholic churches. The lateral walls of the temple terminated in antæ; the columns at the angles were placed opposite the antæ, and far enough distant to admit of another in the interval. The two other columns in front were placed in the line of the walls separating the cellæ.

The following are the proportions of the Tuscan column, as given by Vitruvius. "The columns are to be seven diameters high, their height one-third the width of the temple; the diminution of the shaft one-fourth of the lower diameter; the bases half the lower diameter; and divided in height into two parts, the lower for the circular plinth, and the upper for the torus and apophyge. The height of the capital to be also half the lower diameter; the greatest extent to be equal to twice the height. The plinth, corresponding to the abacus in other orders, is to be one-third the height of the capital, the echinus one-third, and the hypotrachelium with its apophyge one-third." The intercolumniation was areostyle; the architrave was formed of beams of wood, placed one upon another, the height being according to the magnitude of the temple; the beams were joined together by cramps and dovetails; the mutules projected one-fourth of the height of the column, both beyond the architrave and the lateral walls of the temple. The tympanum was constructed either of masonry or timber, and was ornamented with figures in terra-cotta, or gilt bronze.

The ancient Etruscan column probably differed from the Tuscan order as laid down by Vitruvius, and was most likely merely a modification of the ancient Doric derived from Phœnicia. The Greek Doric had no base, because the columns having to support a heavy stone entablature, the intercolumniations were necessarily narrow, and a base would have been inconvenient: but a base was not an unnatural addition. In wooden structures it would be a slab placed below the pillar, to preserve it from the damp of the ground; and was introduced into the Tuscan order, where the intercolumniations were wide, the columns only having to support a wooden epistylium. The Tuscan temple is the simplest and most primitive, the wooden building being as yet only partly exchanged for stone; the mutules are exact imitations of projecting beam ends, without even an attempt at ornament. There was no frieze in the Tuscan order, and the shafts of the columns were never fluted. The whole structure is low and imposing.

At Albano, there are some few fragments of the Tuscan temple of Jupiter Latialis, built by Tarquin the Proud. They were found when the Convent dei Passionanti was built upon its site, and nearly correspond with Vitruvius's description of the order. The sacred architecture of Etruria was more under religious constraint than that of Greece; but if they had one undeviating plan and order for their temples, they, like the Egyptians, allowed their fancy full scope in decorating their tombs and other structures. Capitals have been found in various parts of Etruria, bearing some resemblance to the early Norman, with heads intermixed with volutes and foliage. These are not supposed to be very ancient, and may probably be dated near the fall of Etruria.

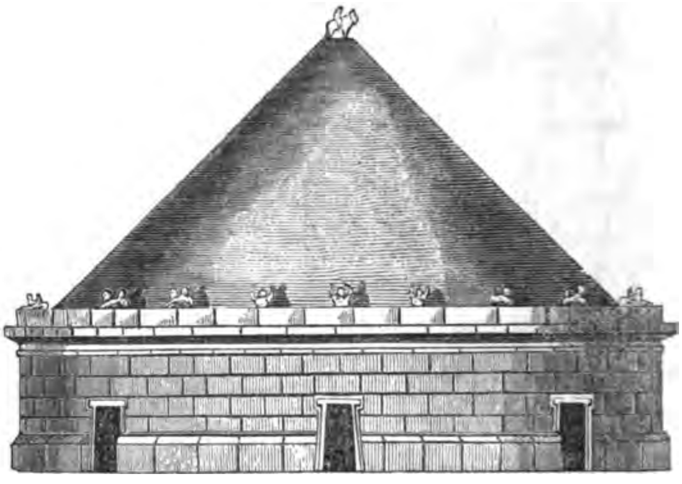
Etruscan Capital, found at Toscanella.

The amphitheatre, with its gladiatorial games, originated with the Etruscans. The Romans imitated these sports, and rendered them still more ferocious by an infusion of their own warlike spirit. It was thought beneath the dignity of a lucumo to join in any public trial of strength or skill; so instead of the refined contests of the Greeks in music, poetry, and athletic exercises, the Etruscans obliged their slaves to combat in the arena, for the amusement of their indolent and luxurious masters. The word amphitheatre is derived from the Greek, and signifies a place formed of two theatres (*amphitheatroi*), or the parts of two circles united, the usual form being an ellipse. The seats were arranged entirely round the arena, so that the spectators could see equally well from all parts of the building. It was appropriated to gladiatorial games, wild beast fights, and similar spectacles.

An Etruscan amphitheatre was discovered at Sutri, by the Marquis of Savorelli, only twelve years ago. The ground is now cleared of rubbish, and the trees removed by which it was overgrown. The plan is somewhat irregular, being carved out of the rock, and the seats and passages formed according to the natural surface. The arena is 164 feet in length, and 132 feet in its greatest breadth. A vaulted corridor surrounds it, into which access is gained by doors in the podium. The seats rise from the podium, or low wall surrounding the arena. To continue the description in the words of Mr. Dennis: "At the interval of every four or five (speaking of the rows of seats), is a prœcincto, or encircling passage, for the convenience of the spectators in reaching ther seats. There are several of these prœcinctiones, and also a broad corridor above the whole, running round the upper edge of the structure. On one side, above the upper corridor, rises a wall of rock, with slender half-columns carved in relief on its face, and a cornice above. In the same wall or cliff are several upright niches, perhaps for statues of presiding gods. Another peculiarity in this amphitheatre is a number of recesses, about half-way up the slope of seats. There are twelve in all, but three are vomitories, and the rest are alcoves, slightly arched over, and containing each a seat of rock, wide enough for two or three persons, probably intended for the magnates of the town. At the southern end is a vomitory on either side of the principal entrance; at the northern on one side only of the gateway. The vomitories have grooves or channels along their walls, to carry off the water that might percolate through the porous tufa. This feature is frequently observed in the rock-hewn sepulchres and roads of Etruria. The vomitories contain flights of steps, separated by landing places. The entrance passage is hewn into the form of a regular vault, sixteen or seventeen feet high, and about the same in width: its length is sixty-eight feet." This is an interesting ruin, showing us the model from which the Romans copied. Of Etruscan domestic architecture we know little, except from the imitation of dwelling-houses in the tombs. Servio, in speaking of Adria, says that the houses had large open vestibules, which were afterwards imitated by the Romans, and by them called atrii. The atrium seems to have been a kind of entrance court, with a pent or roof round it, and a tank in the centre to receive the rain. The roofs of the houses were covered with coloured tiles, and fancifully decorated with masks and other devices.

The same taste for tomb decoration prevailed in Etruria, as amongst the nations of the East. The necropolis was usually on the opposite side of a ravine, or stream of water, which separated the city of the living from that of the dead. Each Etruscan city had some peculiarity in its mode of sepulture, depending in a great measure on the nature of the ground. Castel d' Asso, Norchia, Bieda, and Sovana, are, literally speaking, "cities of the dead;" the low cliffs on either side the roadway being sculptured into the resemblance of the exterior of temples and houses. The rock is chiselled smooth, and the ornaments left in relief; the doorways taper inwards like the Pelasgian, and the whole front has an inclination backwards, as may be seen from the profiles of mouldings in the drawing: the mouldings are frequently carried round the sides of the sepulchre; where this is not the case, one tomb is separated from another by a flight of steps leading to the top of the cliff. In the interior, the sepulchres are generally excavated in imitation of constructed dwellings; the ceilings are carved to resemble low pitched roofs, formed with rafters placed at the angle that would be necessary in a climate like Italy, where snow rarely lies. In some of the rock-chambers, the ceilings are divided by heavy beams into square compartments or lacunaria, which are decorated with painted devices. When the chamber is large, the roof is supported by massive square pillars; at Bomazzo, there is a pillar with a semicircular side facing the entrance; the capital is a square block bevelled off towards the shaft. The sarcophagi, on which the dead recline as if at a banquet, are ranged along the wall: when benches of rock are left to receive the bodies, they are carved into the exact resemblance of couches, with cushions and legs in relief. Like the tombs of Phrygia, many of the doors are fictitious, the real openings being below: like these tombs also, there are instances of perpendicular chimney-like shafts, leading into the chambers. At Bieda, the sepulchres are arranged in terraces, communicating by flights of steps; here detached masses of rock are carved in imitation of houses, with sloping roofs and overhanging eaves. At Norchia, are two very singular temple-like façades; columns have been attached, but they are now broken away; these façades have a frieze with a triglyph-like ornament; the cornice of the pediment terminates on each side, in a volute, within which is a gorgon's head, a favourite sepulchral device; figures are carved in bold relief in the tympanum.

It is singular that in a country like Italy, abounding in artists and learned societies, and traversed year after year by tourists of all nations, such relics of antiquity as these cemeteries could have remained undiscovered until the last half-century, though within a few miles of the high road between Florence and Rome. The necropolis of Sovana, no less rich in excavated tombs than those of Castel d' Asso, and Norchia, was first explored by Mr. Ainsley in 1843. Most of the sepulchres bear inscriptions in the mysterious Etruscan language.



Tumulus at Tarquinii, restored.

In other parts of Etruria, the form of sepulchre was that of a cone or tumulus; these were formed by a low circular wall of masonry, in which were the entrance doors, and surmounted by a cone of earth; the apex was occupied by a figure of a sphinx, and similar figures were ranged along the coping of the wall. The tumulus inclosed several tombs, that of the lucumo, or chief person, being in the central and highest part ofthe cone. This form of sepulchre prevailed at Tarquinii: the necropolis of this city occupied an extent of sixteen miles; 2000 tombs have already been opened, and a rich store of vases, bronze, and gold work, and other curiosities brought to light. In the palmy days of Etruria, the corpse was laid in a carved sarcophagus. Numa Pompilius left directions, "that his body should not be burnt, but should be laid in a stone coffin, after the manner of the Etruscans." In still more ancient times it was the custom to lay the dead on a bier, or funeral bed, clad in armour or robes of state.

Mrs. Hamilton Gray, the accomplished authoress of the 'Tour to the Sepulchres of Etruria,' gives the following account of the opening of a Tarquinian tomb:—"In the year 1826, Carlo Avolto, of Corneto, had a most unexpected glimpse of a Tarquinian lucumo. On removing a few stones from the upper part of a sepulchre, he looked through the aperture to discover the contents, and behold, extended in state, before him lay one of the mighty men of old. He saw him crowned with gold, and clothed in armour; his shield, spear, and arrows were by his side, and the warrior's sleep seemed rather to be of yesterday, than to have endured well nigh thirty centuries. But a sudden change came over the scene, and startled Avolta from his astonished contemplation: a slight tremor, like that of sand in an hour-glass, seemed to agitate the figure, and in a few minutes it vanished into air, and disappeared. When he entered the tomb, the golden crown, some fragments of arms, and a few handsful of dust, were all that marked the last resting-place of this Tarquinian chief."

According to Mr. Dennis, the painted Etruscan tombs only average about one in five hundred; a sufficient number, however, exist to enable us to trace the progress of Etruscan art, from the stiff and ludicrously disproportionate figures of the early ages, to the exquisite grace and sentiment of the most cultivated period. It is a question much discussed, whether the Etruscans copied their art from the Greeks, or whether the Greeks were indebted to the Etruscans. Notwithstanding the tradition of Demaratus of Corinth settling at Tarquinii, with the artists Eucheir and Eugrammus, "cunning hand," and "cunning carver," I am inclined to believe that the love of the arts sprang up amongst each people independently, and, perhaps, simultaneously; and that owing to mutual intercourse, mutual improvement may have taken place. The early, or archaic style, both in Etruria and in Greece, was stiff and rude; but as the arts progressed, the Greek and Etruscan schools (if I may so express it) became more distinct. The Etruscans never attained to that perfection in drawing and matchless grandeur of design, that renders Greek art pre-eminent even at the present day; but they delineated the scenes and feelings they wished to perpetuate, with a grace and tenderness that has only been surpassed by the after-dwellers in the same land—the mediæval artists of Italy.

Etruscan Early Style, from Antique Vase.

Etruscan Later Style, from Tomb at Tarquinii.

The paintings in the sepulchres of Etruria do not represent the avocations of daily life, as in those of Egypt, but generally funeral feasts or processions; or frequently allegorical subjects, such as the contest between the good and evil spirits for the soul of the departed, or the last sad parting scene, where the inexorable angel of death, with uplifted hammer, is about to strike his destined victim, while weeping friends gather round. The Etruscans appear to have used colours conventionally, giving their paintings a somewhat absurd effect to our uninitiated eyes; thus, the countenances of the male figures glow with a brilliant red, emblematical of their state of beatitude, and the horses rejoice in black hoofs and blue tails. They, however, made use of the secondary colours, such as greys and violets—so rarely found in ancient art, and their ornamental borders show an advance of taste beyond the stiff and crude patterns of the Egyptians. The Etruscans never excelled in sculpture, probably owing to the want of material, (Limo, or Carrara marble, not being then quarried); but in moulding in terra-cotta, which Varro calls the mother of statuary, or in metal work, they were unrivalled. We are assured that Etruscan vases of gilt bronze were considered by the Greeks as amongst the most valuable household goods; and the statue of Minerva, the masterpiece of Phidias, was adorned with Tyrrhenian (or Etruscan) sandals.

I have mentioned before that the Etruscan government was founded on an exclusive aristocracy; thus the population was divided into the two classes of nobles and serfs; the latter were employed by their masters in task-work, who were thus enabled to carry out those vast undertakings for which they were so celebrated. We must, however, do the Etruscan lucumones justice, or their clients were not burdened to produce monuments to the selfishness and vain glory of their lords, as in the East, but were occupied in great public works, for the benefit of the whole community. Etruscan roads extended from one end of Italy to the other, and even across the Alps; and noble arches of stone were thrown over rivers and ravines; the Ponte Labadia, and others, still show foundations of Etruscan masonry beneath the Roman repairs. According to Dr. Meyer, the roads were constructed in the following manner:—the ground was dug to the depth of two feet, and beams of charred wood laid as a foundation; upon this was placed silaria, or a composition of earth and stone ground to paste, and then a layer of basalt over all. Another method was to lay terra-cotta or broken stones first, and then to pave with hewn stones upon this foundation. But the most magnificent achievements of the Etruscans were the extensive tunnels and draining, by which the country of Italy was changed from an unhealthy swamp to the garden of Europe. Formerly the heights only were habitable, on account of the malaria: the site of Florence was a lake; and the beautiful Val d'Arno nothing but an unwholesome marsh. A tunnel was cut through Monte Gonfalina, which drained the valley, and enabled it to be brought into cultivation. Tunnels were also excavated at Fiesole, from lakes Meoni and Galano, and other places too numerous to mention: even at the present day, Etruscan emissarii are constantly being discovered. The learned Niebuhr himself first examined the subterranean conduits at Fiesole, in 1820. They also deepened the channels of the rivers, and straightened their course. Land was gained by draining off lakes that had formed in the craters of extinct volcanoes; several such craters exist about Perugia, and though the tunnels have never been cleared out, they still continue to act.

In speaking of the foundation and building of Rome, we have Etruria still under consideration, as far as the arts are concerned; for, however much historians may differ as to the extent of Etruscan political influence at Rome (Müller believing Rome under the Tarquins to have been an integral part of Etruria, and Dr. Arnold supposing the Tarquins to have been independent kings, though of Etruscan lineage), all agree that Rome looked to Etruria for her architects and artists: nor must this Etruscan influence be forgotten, as subsequently it gave the architecture of the Romans its distinctive character from that of the Greeks. This is not the place in which to repeat the well-known legends of Romulus, Numa Pompilius, and the other early kings of Rome, but they cannot be passed by without a regret that so little is known with any certainty about the first few centuries of the once mistress of the world, and that the writings of Numa Pompilius, the thirty books of the Emperor Claudius on the Etruscans, and other works which might have revealed so much, should be lost to the world.

The hills of Rome are low, but steep and rocky; small villages were already scattered over them, and a colony was established on the Palatine when Romulus and Remus arrived to take possession with their shepherd band. They proceeded to mark out the first boundary of the future Rome, about the year 753, B.C. Romulus marked out the pomœrium round the Palatine, according to the Etruscan ceremonial; and it was for contemptuously leaping over the sacred furrow that Remus lost his life. The pomœrium was a space left both within and without the walls of Etruscan cities;—the word is variously derived from *post murum*, or *pone muros*, or *proximum muro:* it was never built upon, nor applied to agricultural purposes, but was used by the augurs in taking the city auspices. The pomœrium was carried further out as the city was enlarged, and its boundaries marked by cippi, or termini. When the foundation of a new city was to be laid, a favourable day was appointed by the augurs for marking out the boundary; a line was first drawn with white earth or sand; a copper share was then fixed to a plough, to which were yoked a bullock and a heifer; the plough was guided along the line by the chief or king. Both the animals were to be white, to denote the simplicity and purity in which the citizens ought to live. The bullock was placed on the outside, or next the country, to show that it depended upon the men to cultivate the land and guard the public safety, by watching over what might take place without the walls; the heifer was turned towards the city, significant of the household and domestic cares devolving on the female. The plough was guided so that all the clods should fall inwards, another person following to see that none remained outside: this was to teach the people to gather together within the city all that could contribute to its increase and prosperity, and to leave nothing beyond its limits that could be hurtful to it, or advantageous to its enemies. The sacred plough was lifted over the place where the gates were to be, otherwise no dead body or unclean thing might have been carried out. The new city was then placed under the protection of some divinity, by a secret name, that its enemies might not be able to divert the divine favour: it is said the secret name of Rome was Valentia. At the founding of Rome a subterranean vault was constructed under the place called the Comitium; this vault was filled with the firstlings of all the natural productions used as food, and with earth brought from the native place of each of the mixed people that were to form the future population of Rome. The vault was called Mundus, and was believed to be the entrance-gate to the world of spirits; the door was opened three days in the course of the year, to allow the souls of the dead to enter. Lucerum, on the Cœlian, supposed to have been an Etruscan settlement, was first united with the Palatine; then the hill of the Sabines, in early times called the Agonian, but afterwards the Quirinal, of which the Capitoline was the citadel. After the rape of the Sabines and its consequences, when these two cities of Rome and Quirinum had united on equal terms, the temple of the Double Janus was built on the road between the two hills, with a door facing each city; these doors were open during war, that succour might pass between the allies, but closed in time of peace, to denote their being distinct though united. By degrees, as union was cemented, and friendship fostered by intermarriage and a common religion, the two cities agreed to have but one king, and one senate, and thus became incorporated. Ancus Martius built the first bridge over the Tiber, and a fort on the Janiculum. The bridge was a kind of wooden draw-bridge, the Tiber being the great division between Etruria and the kingdoms of the south: it was not until several centuries after the establishment of the Commonwealth, when the Roman dominion had become enlarged and consolidated, that a permanent stone bridge was built. The prison, the most ancient building now existing in Rome, is also said to be of the time of Ancus Martius. The splendour of Rome began with Tarquinius Priscus; under this king the city, with its seven districts, was surrounded by a stone wall. The wall was built along the outside edge of the Quirinal, Capitoline, Aventine, and Cœlian hills; from the Cœlian it extended to the Esquiline, where a high rampart, strengthened by towers, was raised from the Esquiline to the northern side of the Quirinal. This rampart was 50 feet in width, and above 60 feet in height; the moat out of which the puzzolano was dug with which the wall was constructed, was 100 feet in breadth, and 50 feet in depth: the rampart was faced with flag-stones on the side next the moat. Much of the space within the wall at that time (considerably more than the usual pomœrium) was entirely uninhabited and uncultivated, and might almost appear to have been inclosed in a prophetic spirit, foreshadowing the increase and glory of Rome. The Viminal, when thus inclosed, was overgrown with osier thickets, and the Esquiline took its name from the oak-woods with which it was covered. The herdsmen, with their cattle, took refuge within the walls in time of war. These fortifications would seem to imply Etruscan domination; for as Rome was situated at the southern verge of their kingdom, they would naturally make it a stronghold against the southern states; but would scarcely have sent Etruscan artificers to an infant city to fortify and adorn it, when it might turn its strength against them as soon as completed—an event which occurred on the expulsion of the Tarquins. That Rome, during the first few centuries, was in itself insignificant, is evident from the fact, that while the Greeks held constant intercourse with Etruria, Rome was scarcely known to them before the time of Alexander the Great. The first mention of the name is found in the writings of Theopompus, who lived in the time of Philip of Macedon; and Heraclides of Pontus, a disciple of Aristotle, mistakes Rome for a Greek maritime city, and mentions it as being attacked by a fleet of Hyperboreans, instead of by the Gauls.

It is doubtful whether the erection of the Capitoline temple of Jupiter is to be ascribed to the first or second Tarquin. It was built after the Etruscan manner, though on a more splendid scale than usual; for the portico which faced the Palatine had a triple row of columns, while a double peristyle inclosed the sides: the foundations of the ancient structure are still in existence. A chariot of terra-cotta was ordered to be prepared at Veii, to ornament the pediment of the Capitoline temple. When the chariot was in the furnace, the clay was observed, instead of contracting as usual, to expand, so that the workmen were obliged to take down the furnace to get it out. On consulting the augurs respecting this miracle, it was decided that it was an omen of increased diminion to whichever city should obtain possession of the chariot. The Veiientes, upon hearing this, determined to keep it themselves, making an excuse that the Romans had forfeited their right to it by the expulsion of the Tarquins, by whom it had been ordered. Soon after, a chariot race took place at Veii, when, to the consternation of the people, the horse of the winner took fright without any apparent cause, dashed along as far as Rome, to the foot of the Capitoline-hill, where the charioteer was thrown out and killed on the spot. The people of Veii imagined this catastrophe to be a warning from the gods, and immediately gave up the contested chariot to the Romans, who placed it in triumph on the pediment of their temple.

The most celebrated of the Etruscan works in Rome, is the great Cloaca Maxima, which pours its river-like water into the Tiber, after draining the Velabrum and the valley of the Circus, previously an uninhabitable swamp. This great cloaca is composed of three semicircular arches, one within the other; the span of the innermost being 14 feet, and formed of hewn blocks of peperino, fitted without cement. Another great drain running into it was only discovered in 1742. In short, it is affirmed by some authors that Rome was subterraneously navigable. Public officers were appointed to keep the sewers in repair, called "Curatores cloacarum Urbis." On the land reclaimed by means of these drains, Tarquinius granted space for a forum, round which porticoes were erected. He also allotted another part of the redeemed ground for a circus. The building materials of the Romans at this time, was confined to the peperino of the quarries of Alba and Gabii, the tufa of the Campagna, and the porous travatine of the Anio—materials wholly unsuited to decorative architecture.

In the year 509, B.C., Tarquinius Superbus was driven from Rome, and the Commonwealth declared. From this time until the commencement of the Empire, the people were occupied with unceasing wars, and no great architectural works were executed. Soon after the banishment of Tarquinius and his family, Tarquinii, the capital of Etruria, was destroyed. After this the Etruscans gradually lost power and influence, though they preserved their peculiar religious rites till the Christian era. One by one, the great Etruscan cities fell, till the country passed under the dominion of Rome, in the time of Scylla, 90 B.C.

From the time of its subjugation to the last half century, Etruria was almost a forgotten name. Within the last few years much interest has been excited, and many valuable works written; and there is little doubt that future research will throw yet more light upon the arts and history of the once refined and powerful Etruscans.

In my next lecture, I shall begin the history of Greek architecture; commencing with an inquiry into its origin, and the causes of its pre-eminence.

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ON THE EXPLOSION OF STEAM-ENGINE BOILERS.

Of late years, and more particularly during the last few months, steam-engine boiler explosions, both in this country and in the United States of America, have been of very frequent recurrence.

The awful sacrifice of human life, and great destruction of property usually attendant on them, invest these matters with grave interest.

In the United States, high-pressure steam is commonly employed; essentially so in the steamboats which navigate the Delaware, the Hudson, and the Mississippi. In the United Kingdom, although high-pressure steam-engines *are* used, yet the employment of them may be considered as the exception, not the rule.

Anomalous as it may seem, it is nevertheless true, that explosions of the kind, in this kingdom, more frequently take place with boilers worked either at low, or at moderate rates of pressure, than with those worked at high. We wish particularly to impress this knowledge on the public mind. It is essential to the interests of the community that it should be so. A want of that knowledge, combined with the erroneous opinions which generally prevail on the cause of steam-boiler explosions, and which attribute such accidents, almost universally, to great intensities of pressure of steam, or the liberation of the gases, have, we are induced to believe, been the cause of many such catastrophes. When, therefore, we reflect how important it is for the proprietor of a steam-engine, as well for his own pecuniary interests as the personal safety of those who are employed by him, to be acquainted with every minute particular of matters of this nature, we are led to explain, what, in our opinion, is one primary cause of such explosions.

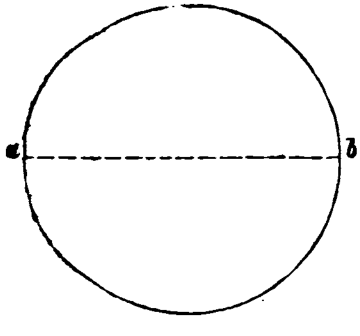


Fig. 2.

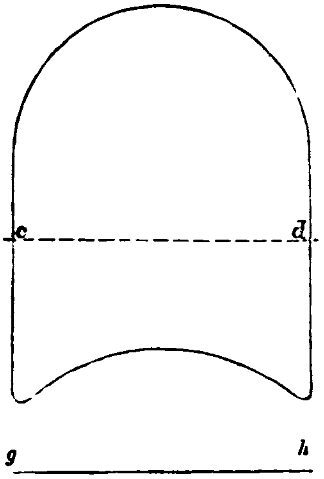


Fig. 1.

In the preceding woodcuts, fig. 1, represents a vertical section, and fig. 2, a plan of the underneath part of a circular-shaped boiler, concave at the bottom, and hemispherical or domed over at the top; not uncommon in the mining districts of the kingdom. Boilers of this kind, from having been extensively adopted by the eminent engineer, are not unfrequently called, the "*Smeaton-boiler.*" By other persons, the "*egg-boiler,*" from its appearance, when rising above the brickwork, assimilating to that of an egg in its cup.

It has fallen to our lot to witness, during our professional practice, the destructive effects of explosion, as produced by two boilers of this peculiar construction: one in Lancashire, the other in Staffordshire. In both instances, the boilers, though of great weight, were lifted from their seats, and blown to almost incredible distances. Yet, the boilers were employed ordinarily in generating low-pressure steam; and, so far as could be ascertained, there was no reason to doubt that, at the time, either of them was acting otherwise than in the usual manner. Numerous opinions, entirely of a speculative character, were advanced as to the causes of these explosions. Most of them hinged, as is usual in such cases, either on the supposition that the safety-valve was defective, which allowed of an undue augmentation of steam in the boiler, until it attained to a pressure that could not be resisted; or, to the non-effective working of the hot-water pump, which, by not supplying the boiler with water to compensate for that vapourised, allowed the metal of the boiler to become so heated by the action of the fire, as eventually to absorb the oxygen from a portion of the water, and thereby liberate its other constituent, *the hydrogen,*—whereby, in the opinions of such persons, explosions do take place. We, from our own examinations, entertained very different thoughts at the time, although we had not occasion publicly to avow them. Since those periods, the personal inspection of numerous boilers have confirmed the impressions we then entertained.

We shall now endeavour to elucidate, by familiar exposition, the causes of such explosions; and we do so the more willingly, as we are in the hope that much good may be educed, by eliciting the attention of engine proprietors and engine-tenters to the matter. We must state, however, in the first place, that as we have not got by us, convenient for reference, the dimensions of the two boilers, to whose explosions we have referred, we shall, for the argument, take supposititious dimensions.

Suppose the diameter of the circular part of each boiler, at *a*, *b*, or *c*, *d*, to have been 12 feet, and that, for sake of simplification, the curved top and bottom parts of the boiler, though convex and concave, be considered to have been flat,—each presenting the same diameter of 12 feet; under such circumstances, the area of the top and bottom plates, respectively, would have been 16,286 inches. If, therefore, the presure of the steam within the boiler ranged no higher than 12 lb. beyond the atmosphere, the total amount of pressure on the top and bottom plates would not have been less than 195,432 lb., or about 87½ tons each.

Now, if we examine attentively the nature of this pressure, or force, we shall perceive that, so long as the boiler remains sound, or is in good condition, this enormous amount of power acts equally, *and internally*, both against the bottom of the boiler with a tendency to force it the more firmly on its seating of brick-work and against the top of the boiler with an inverse tendency to project it into the air on the principle of the sky-rocket. Both forces being equal, and acting in opposite directions, balance one another. Hence, so long as the boiler remains sound, these conditions are undisturbed, and the action of the force is equivalent to that of statical equilibrium. The boiler, therefore, has no tendency to ascend or descend, by virtue of that pressure; but is retained on its seat by the weight of the metal of which it is composed, and the weight of the water within it.

Suppose, however, on the other hand, that from long usage, and consequent weakening of the boiler by the action of the fire upon it, a rent, or considerable fracture of the metal, takes place below, so as to allow of a sudden and comparatively large escape of heated water into the flue, or space *g*, *h*, and on and against the red-hot brick-work. The consequences then become frightful. The pressure on the top and bottom of the boiler, *internally*, still balance one another, minus the less amount of pressure on the bottom, caused by removal of that portion of the metal displaced by the fracture. But underneath the boiler, between it and the brick-work, the destructive effect of the pressure—caused by instantaneous evolutions of large bodies of steam from the heated water and heated brick-work—becomes alarmingly great. It is of itself amply sufficient, without extraneous aid, to account for all those devastating and painful casualties we are accustomed to witness at such times.

We repeat that, just before, and immediately subsequent to the fracture, the pressures in the interior of the boiler are equal, minus the less amount of pressure on the bottom, subducted by the opening made by the rent. But beneath the boiler, the pressure acts equally against the brick-work of the flue, *g*, *h*, and the under-side of the bottom part of the boiler; and as this latter is unconnected with its seating of brick-work excepting by its weight, which in a boiler of that construction, does not, with its complement of water, often exceed twenty tons, the projection of the boiler into the atmosphere is the inevitable result.

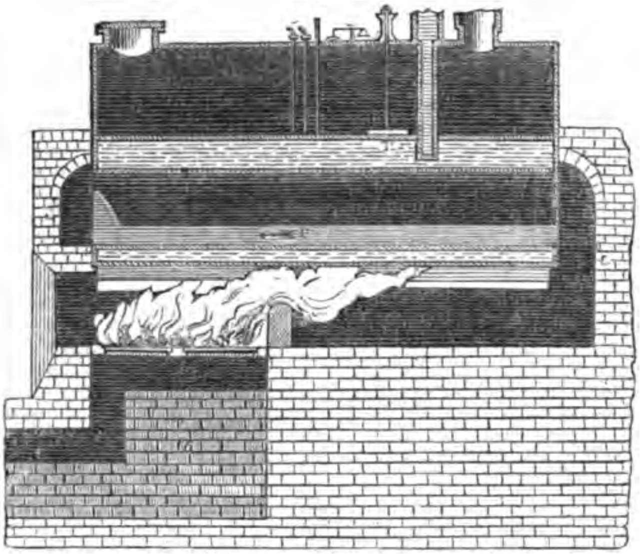
It is not possible to determine what the amount of that projectile force may be. For, when the fracture takes place, and the water, by escape, occupies a greater space, the pressure of the steam is most probably diminished in the interior of the boiler, although acting with equal intensity of force *as regards that pressure*, both against the top and bottom of the boiler internally. But beneath the boiler the pressure is augmented to an enormous extent, partly by large bodies of the heated water—already at the temperature 245°—flashing, when liberated, instantaneously into steam; and partly by other quantities of such water being projected against the red-hot brickwork of the flue, and on the large mass of ignited coal on the fire-grate—and, by suddenly absorbing from such sources other and large quantities of caloric, being as instantaneously flashed into steam. It should also be borne in mind, that the additional quantities of steam thus generated exert no force whatever inside the boiler, or comparatively none; and that the whole amount of the pressure is directed against the exterior of the boiler, increasing, largely, the projectile power.

Suppose, therefore, that the amount of pressure lost by the escape of the water into a larger space, at the time of the fracture, to be reinstated by the additional quantities of steam thus suddenly evolved (and we think it quite possible), it will be perceived that, in such case, the pressure exerted against the under-side of the boiler by the newly-evolved steam, is 87½ tons; that the resistance to that force is derived only from the weight of the boiler, and the water within it, together amounting, probably, to 17½ tons; and that the projectile force is equal to 70 tons. Hence, the boiler must be blown from its seating, and projected through the air, and the brickwork be scattered in every direction. But even if we admit the force, as exerted by the pressure, to be equal only to one-half of that amount, or 35 tons, still *being derived from an elastic agent*, it is amply sufficient to produce all those devastating effects, which, under such circumstances, we are accustomed to see recorded.

The direction that an exploded boiler may take in its flight most probably is influenced by the position of the fracture. This will be better understood by reference to the subjoined diagram (*see next page*).

In the preceding section let fig. 3 represent a wagon-shaped steam-engine boiler, set in the usual manner, in brickwork. By the arrangement, as thus exhibited, the flame, and heat, and gaseous products of combustion, pass from the fire-grate over the bridge, along the bricked flues beneath the boiler, and at the back of it;

thence through the metallic flue of the boiler, into the bricked flue at the front of the boiler, where the current divides itself, and passes through two brick flues, arranged one on each side of the boiler, into the ordinary damper-flue, whence it passes into the chimney.



By examining the diagram it will be at once obvious that, as the flame and heat flow continuously over the bridge, and through the flues beneath, and at the end of the boiler, the brick-work of those flues must imbibe so much caloric as to become red-hot. Further, that should any fracture or rent of the boiler take place, so as to allow of a portion of the heated water to flow thence, on that red-hot brick-work, enormous volumes of steam must be *instantaneously* generated—capable, by that agency alone, of producing all those disastrous effects to which we have referred. In a wagon-shaped boiler, however, the effects, under the same pressure, will be greater than with the Smeaton or egg-shaped boiler, by consequence of the greater area exposed to the pressure.

It is well-known, naturally, that all power is transmitted in a right line, and that the operation of compound forces is necessary to produce any deviation from it. If, therefore, the steam thus suddenly evolved from the heated water by its coming into contact with the red-hot brick-work of the flue, could, at the same instant of time, be equally diffused under every portion of the bottom only of the boiler, and act on every part of it with equal intensity of pressure, there is not a question that the boiler would be projected vertically into the air. But such range of flight is barely likely to take place. Even if the steam could be equally diffused under every portion of the bottom part of the boiler at the same time, the fire-grate, owing to the interstices between the fire-bars, does not present that firm base for the steam to act against as is presented by the solid mass of brickwork behind the bridge. Therefore, the great probability is, should any such fracture take place, either over the bridge, or on the right-hand side of it, or over the flue, to however small an extent, the boiler will be projected through the air in an oblique direction; and the deviation from the vertical line will be greater or less, accordingly as the fracture takes place nearer to, or farther from, the bridge, towards the chimney. The greater accession of heat, also, that may be imparted to the water by such brick-work, and the action of the pressure on the end of the boiler, at the flue will tend, still further, to the oblique direction we have stated.

The observations we have thus made are of great practical importance. Hitherto, from the awful effects of such explosions, the minds of practical and thinking men have been devoted more to a search after some unexplained cause for increased production of pressure within the boiler, rather than to an elucidation of the simple one we have developed, and by which, in our opinion, most of those catastrophes are produced. High-pressure steam is not indispensably necessary to an explosion. Low-pressure steam is amply commensurate to the end. We have shown this by our remarks on the explosions that took place of the two Smeaton or egg-shaped boilers; and we can confirm or strengthen the statements by adding, that we were present shortly after, and witnessed the effects that had been produced by an explosion of a wagon-shaped boiler. It had been worked, customarily, at from 7 to 9lb. pressure on the square inch, and there was reason to believe that that pressure had not been exceeded at that time. It was in connection with two other boilers, neither of which had exploded. In short, it is to neglect, superinduced by a false notion of security, that such explosions may, in general, be attributed. Engine proprietors and engine-tenters, not having been aware of the danger, have, until now, been indifferent, comparatively, as to any defective state of a low-pressure boiler. How frequently do we see such, while working, leaking badly; but not sufficiently to produce an explosion. How often do we hear that the engine-tenter, even with the sanction of his employer, has had recourse to some paltry patchwork of a contrivance, to prevent a defective boiler from extinguishing the fire. Had the danger we have pointed out been known, would such things have been allowed to exist? Both the engine-proprietor and engine-tenter would, for their own interests, have been averse to it. It cannot, therefore, be too well-known that steam-engine boilers are, by neglect, quite as liable to be exploded when worked at low rates of pressure as at high. Nor can the reasons we have thus assigned as the cause of such explosions be too widely disseminated.

IMPACT OF ELASTIC BEAMS.

On the Impact of Elastic Beams: Abstract of a paper read before the Cambridge Philosophical Society, Dec. 10, 1849. By HOMERSHAM COX, B.A. Jesus College. [From the *Philosophical Magazine.*]

"Among the experiments instituted by the Royal Commission, appointed to inquire respecting the use of iron in railway structures, was a series relating to impact on beams. These experiments were undertaken by Professor Hodgkinson, and were conducted in the following manner. The two ends of the beam were fixed in a horizontal position, and the blow was given against one of its vertical sides, in a horizontal direction. The instrument for giving the blow was a heavy iron ball, hanging down, when at rest, from a point of suspension vertically above the centre of the beam. The ball was raised through different arcs, and after descending by its own gravity struck the beam. The deflection corresponding to different arcs of descent were carefully noted by a graduated scale. The object of the present paper is to show that the results might have been predicted by known theoretical principles with considerable accuracy. The problem is divided into two parts: 1st—to estimate the amount of velocity lost by the ball at the first instant of collision; 2nd—to ascertain the effect of the elastic forces of the beam in destroying the *vis vivâ* which the whole system has immediately after collision.

"In the first part of the investigation a general formula, derived from the combination of D'Alembert's principle and the principle of Vertical Velocities, is given for the motion of any material system subject to impact. The requisite geometrical condition required for the application of this general formula, is obtained by the assumption that immediately after impact, the form of the beam is a gradual and tolerably uniform curve, such as, for example, the elastic curve of equilibrium. In this way it is determined that about one-half the inertia of the beam is effectively applied at the instant of collision to retard the ball.

"The *vis vivâ* of the whole system thus computed, is destroyed by the elastic forces of the beam developed by deflection. These, in the second part of the problem, are assumed to vary as the amount of the central deflection. By the principle of *vis vivâ* a formula is easily obtained, connecting the total deflection with the *vis vivâ* of the system immediately after collision.

"Tables are given, in which the theoretical and experimental results are compared. The correspondence is of the closest and most satisfactory nature. Indeed, the theoretical results generally differ less from the mean of several experiments, than those experiments differ among themselves. Both in the theoretical and experimental inquiries, every possible variation of the elements of the investigation—the relative masses of the beam and ball—the velocity of the latter—the rigidity and dimensions of the former—have been included."

THE MAUSOLEUM OF HADRIAN.

On the Mausoleum of Hadrian, now the Forte St. Angelo, at Rome. By the Rev. RICHARD BURGESS, B.D.—(Paper read at the Royal Institute of British Architects, March 4th.)

IT is remarkable how much knowledge of the habits, occupations, and even religion of an ancient people may be gained from the kind of edifices their architects were called to construct. So much so, that, if the pages of history were blotted out, the dumb monuments, which time has spared, would speak to us of the recreations, the morals, the mode of life, and even the mode of death adopted by the ancient Greeks and Romans. In no age has the architect the choice of the kind of buildings he would erect. His business is to give shape and proportion to the edifices which the climate, the habits, the religion or the popular pursuits of a people demanded. The buildings of ancient Rome, which afforded the most ample scope for architectural skill, would not be required, for instance, in our metropolis. The buildings, which gave scope for the architect's skill, the porticoes, theatres, baths, are lost to our time and climate.

It is with special reference to sepulchral monuments that I have introduced these preliminary remarks. These afforded a field for the architect of classic times, which in our day has been entirely transferred to the stonemason. The pyramids in Egypt, the monument of Philopappus at Athens, and the sepulchres of Augustus and Hadrian at Rome, were among the most conspicuous edifices of their respective countries and ages. But where now should we find a tomb in our public cemeteries or grave yards which would require any skill to construct, beyond what might be found in a very moderate artist? I speak not of the monuments of our great men, which the art of sculpture has touched, and which stand under the shelter of a cathedral vault. Speaking, as I intend to do, of sepulchral monuments as buildings, I have yet to ascertain the cause why this class of edifice has been lost to the modern architect. The cause is in the change which Christianity has wrought in the hopes and prospects of what may happen after death. The ancients considered a tomb in a much more important light than we either can or ought to do. So feeble were their expectations of living in their fancied elysium, that they generally looked forward to the honour of a tomb, as the only blessing that awaited them. Hence the anxiety so frequently discovered on monumental inscriptions, which the individual during lifetime had for providing for himself and his family a place of burial free from intrusion. The initials, "H. S. F. V."—*Hoc sibi fecit vivus:* "He made this for himself while he was alive"—we constantly find on ancient tombs. And we cannot wonder, that the wealthy, under these circumstances, should have bestowed so much of their substance in erecting their private monuments, and the warrior and the statesman so much care and toil in gaining this as a public honour.

The ancient Romans erected their splendid tombs by the sides of the public roads, and from the remains still existing along the Via Appia, that road might, without any further indications, be traced for at least four miles from Rome. The sepulchres of the Scipios, the Metelli, and the Servilii are enumerated by Cicero as amongst the tombs which stood without the Porta Capena. And he thinks, that no one, looking on those monuments of the illustrious dead, can esteem the buried inmates unfortunate. This was all the immortality to which the Egyptian Pharoahs, the Athenian sages, or the Roman generals aspired; and therefore the more durable the monument, and the more conspicuous its massive walls, the more the honour, the greater the consolation. Palinurus was soothed by the assurance, which Æneas gave his wandering ghost, that he should have a Cape called after his name, which would be more durable than even a mausoleum.

> Æternumque locus Palinuri nomen habebit
> His dictis curæ emotæ
> gaudet cognomine terra.——Virg. Æn. vi. 382.

The early sepulchres of the Republic at Rome were of that kind called "Hypogæa," that is, chambers underground, with an elevation little more than enough to exhibit the inscription to the passers by. Such were the sepulchres of the Scipios, as it is yet to be seen near the Porta St. Sebastiano. But towards the end of the Republic, when the luxury of marble began to be known, and governors of provinces returned home laden with the spoils of the East, the colossal taste in sepulchral monuments was introduced. The rich Crassus erected a mausoleum for his wife on the Via Appia, built of travertine stone, twenty-four feet thick; and every one who has visited the Campagna at Rome, will be familiar with the striking monument of Cecilia Metella. Forsyth observes, "the general form of the tombs on the Appian Way, is a cylinder or a truncated cone with a cubic base and a convex top. This combination," he says, "conveys the idea of a funeral pyre, and has some tendency to the pyramid, the figure most appropriate to a tomb, as representing the earth heaped on a grave, or the stone piled on a military barrow." Perhaps Crassus was the first who broke through this general rule, when he gave more rotundity to his wife's monument. Caius Cestius went back to the pyramid: and these two monuments, which we may consider as belonging to the Republic, have now stood for nearly 2,000 years, and there seems no reason why they should not stand for 2,000 more.

But I come now to the two great sepulchres of Imperial Rome. Augustus chose for the site of his mausoleum a place in the Campus Martius, between the Via Flaminia and the Tiber. The remains of that monument are now to be seen behind the Palazzo Corea, near the Porto di Ripetta. The ancient walls are so concealed or involved with the surrounding buildings that its magnitude can hardly be estimated by the spectator. Strabo has given us some description of it, and he considered it the object most worthy of notice among the splendid edifices of the Campus Martius. It stood upon a lofty substruction of white stone, near the bank of the river; and it was shaded to the very top by evergreen trees. The summit was crowned by the statue of Augustus in bronze. The trees appear to have been planted on the belts of the stories, as the circumference contracted towards the top. Behind the mausoleum there was a grove laid out in walks, the care of which was committed to a procurator. The tomb was built twenty-seven years before the Christian era, and it is probable that the boy Marcellus was the first of the imperial family interred within its walls.

> quæ, Tiberine, videbis
> Funera, cum, tumulum præterlabere recentem!

It was in this tomb that Agrippa and Drusus were buried. And in the nineteenth year of the Christian era, Agrippina, in the midst of weeping crowds of citizens, brought the ashes of Germanicus to be placed within its walls. But the monument, which was designed by the first master of the Roman world to be the silent repository of the ashes of himself and his posterity, has come to an ignoble end. The ruins, which time and Robert Guiscard the Norman, have left, are now consolidated into the platform of an amphitheatre; and in the summer months, several thousands of the Roman people sit round the ample circumference, to witness the horrors of a bull-fight, the feats of horsemanship, and the antics of a vagrant clown. I have mentioned this monument, in many respects similar to that of Hadrian, in order that I may with advantage introduce the subject which has been announced for this evening.

As if it were to show how little any works, however great, are valued, which have not some public object or utility, this colossal monument, which we are about to view, is hardly noticed by the ancient writers. But there is little doubt that the emperor Hadrian himself was the architect of his own tomb: the whole of his life was dedicated to the arts, and he could ill brook a rival in the science on which he thought he excelled. Apollodorus, the great architect of that day, the man of taste, was doomed to view all the designs the emperor sent him, and to choose between praising what he could not admire, or going into exile. Appollodorus ended in the latter alternative, and left the imperial architect to construct his own mausoleum. Dion Cassius tells us, that when Hadrian was buried in the tomb he built on the bank of the Tiber, that of Augustus was full, and no more ashes could be deposited within it. But I apprehend that Hadrian had cast an emulous eye upon the great work of his predecessor, and perhaps chosen the garden of Domitia, nearly opposite, to confront with greater splendour the monument which Strabo had praised; the rich materials he had probably collected in his travels through the empire, and I imagine like those, who built a still larger tower in the plains of Shinar, the vain notion of his mind might be expressed in the same language—"Come let us make us a name." Be this as it may, all that Spartian, the biographer of Hadrian, tells us about this stupendous work is, "*Fecit et sui nominis pontem et sepulchrum juxta Tiberim.*" The bridge here mentioned, is that which Hadrian erected across the Tiber to give an easy access to his tomb, and which he called Pons Elius, after his prenomen. There is a medal extant, which exhibits this bridge with three main arches in the middle, and at each end two of smaller dimensions. Much of the ancient construction of peperine stone still remains in the vaults of the arches, and with the name changed to Ponte S. Angelo, it preserves to this day the appearance of what it was originally. I am fortunate enough to be able to point to some exquisite drawings of the arabesque ornaments of some of the vaults and ceilings in the modern compartment; these have been kindly furnished to me for the occasion by the obligeance of M. Grüner, the author, honorary and corresponding member of this Institute.

It appears from various inscriptions that have been found and preserved, that this mausoleum received the ashes of all the Antonines; and the body of Commodus, after being dragged through the Tiber, was also buried in it by order of Pertinax. Something was left by Hadrian for his successors to finish, and it probably continued to be the imperial place of burial until the time of Septimus Severus; perhaps we may say to the middle of the third century. Then its history as a sepulchre ends. But, before I proceed to describe to you the original appearance and splendour of this monument of Imperial Rome, let me bring together the few notices which are found of it in ancient writers. Procopius is the first who gives any description of what it was, in his account of an assault made by the Goths outside the Aurelian gate (that is not far from where the Gauls of 1848 very recently made their assault); he thus writes—"The tomb of the Emperor Hadrian is situated outside the Porta Aurelia, about a stone's cast from the bulwarks of the city, it is an object worthy of admiration. It is built of Parian marble, and the blocks fit close to one another without anything between to fasten them; it has four equal sides about a stone's throw in length; it rises above the city walls; on the top are statues of the same kind of marble, admirable figures of men and horses. The men of old time (that is the Romans, probably, in the time of Honorius), joined this monument with the bulwarks of the city by two walls, because it appeared advantageous for the defence of the city; it thus became a part of the fortifications, and had the appearance of a lofty tower covering the entrance of the city." So far we learn that the mausoleum was converted at a very early period (for Procopius saw it in 534 A.D.) into a fortress. Those beautiful statues, however, which the secretary of Belisarius describes, were put to a strange use by the defenders of Rome. Instead of more appropriate missiles and more raw material, these masterpieces of sculpture were torn from their pedestals and hurled upon the besiegers below; and perhaps the breaking of the head of a Goth might cost a whole Venus or a Mars, a head of a Faun, or a foot of Hercules. I do not know what to say of a passage cited by Salmasius from John of Antioch, who lived A.D. 620. "The figure of Hadrian," he says, "stood on the top in a car drawn by four horses, of such colossal dimensions, that a full grown man might pass through one of the horse's eyes." A chronicler of the thirteenth century, commonly called the Anonymous, says that the tomb was faced with marble, and he talks of gilded peacocks and a bull. The same mediæval sight-seer mentions also bronze doors and horses, which he saw about the mausoleum. But the earliest representation or drawing we have of the mole is that now existing on the bronze doors of St. Peter's, made in the days of Pope Eugenius, by Antonio Pollagio, about 1481. In Camucci's sketch, made a century later, some of the cornice is indicated which he must have seen, and which he says was embellished with ox-heads and festoons; and on the frieze there were two inscriptions then to be seen belonging to Commodus and Lucius Verus. Pope Clement VII. and his architect Labacco gave currency to the tradition, that the beautiful columns of Paonazzetto, which stood in St. Paul's Basilica, once adorned the upper stories of this mausoleum. Now with these notices of historians and artists of old time, added to our own observations of its present state, we are to make the description, both external and internal, of this durable monument.

The mausoleum was formed of a square basement, which measured 253 feet on each side, making a perimeter of 1012 feet. The door, or entrance, was in the middle of the south side, facing the passage across the bridge. At the four angles of this solid basement were colossal statues, or trophies; I rather suppose them to have been those horses which are mentioned by the monk of Antioch; in the centre of this massive foundation, which was adorned by festoons and bucrani, rose the round tower, which still, in a great measure, exists and serves as the donjon or keep of the castle. This tower did not diminish towards the top as some have supposed, for Procopius measures the diameter at the top by the same expression of a stone's cast, as he measures it at the bottom; though diminished by all the marble facings in width, it still yields a diameter of 188 feet. The round mass was compacted together of peperine stone and the usual materials employed in solid Roman works; but it was all faced with square blocks of Parian marble. We must accede to the generally received opinion that two magnificent colonnades went round the monument, dividing it into two stories, and that statues stood in the intercolumniations. Those statues were probably *chefs d'œuvre* of art. The famous Barberini Faun, which was found by the pontiff of that name in a ditch of the fort is a specimen; the dancing faun in the Florentine Gallery is another; these had either fallen from their place, or had been used by the troops of Belisarius for overwhelming their assailants. The summit of the edifice, which finished in a dome-shaped roof, was crowned, as some think, by the large bronze pine found in digging the foundations of S. Maria Transpontine, and which is now to be seen in the gardens of the Vatican. But it was more in conformity with the ambition of the Roman emperors to have their statues erected on the summit of their monuments: witness the columns of Trajan and Marcus Aurelius, and the corresponding sepulchre of Augustus. The bronze pine would be a more appropriate ornament for some edifice in the gardens of Domitia, in which the mausoleum was erected. Moreover, we have it stated by one of the ancient writers I have quoted, that there was the statue of Hadrian somewhere about the tomb. I have therefore, in spite of some celebrated antiquarians, taken the liberty to place the statue of Hadrian on the top of his mausoleum. From the intimation we have of the ox-heads and festoons, and the inscriptions on the frieze, I have represented the basement as Doric; the first row of columns above would naturally be Ionic; and if the columns of St. Paul's Basilica were really taken from this tomb, they speak for themselves, and will justify us in exhibiting the upper row in the glory of the Corinthian. Upon these data and surmises, therefore, I have presented to you the mausoleum in its exterior, as I suppose it originally to have been; and we may safely conclude that it remained in all its pristine magnificence until the time of the Emperor Honorius, 402. Let us now go within. The spiral corridor, which leads from the entrance to the sepulchral chamber, was entirely excavated in 1820. Beginning from the original entrance facing the bridge, a lofty arch of travertine stone forms the ingress, and leads into a spacious vestibule. Opposite the position of the door of entrance there is a large niche, which no doubt contained the statue of the emperor; a colossal head, now in the Vatican, and a hand discovered in the excavations, probably belonged to the said statue. In a compartment on the left side of the niche is a fragment of a cinerary vase of marble, with some letters upon it, which was lying there when I examined the interior of this monument in 1829. The spiral corridor, by which we now begin to ascend, is about 11 feet in width and 30 feet in height, built of the finest brickwork; the bricks 6 feet long; but the whole has been coated with precious marbles, as appears from the continual fragments still found, and the traces of them yet sticking to the walls. The ascent is not by steps, but by a gently inclined plane, winding round the monument, and showing specimens of the mosaic flooring still adhering to their original places. This wonderful passage was lighted from above by those openings called in Italian *abbaini;* they are cut through the massive covering in pyramidal forms. The light cannot enter by them now on account of the modern works of the forte, which lie over them; and hence this corridor can only be seen by means of torches at present. Pursuing this circular passage we ascend until we arrive where the modern staircase and the light of day meet us, and turning by an arch we come upon the sepulchral chamber. It occupies a space of about 25 feet square, and is lighted by a window at each side, which exhibit at the same time the immense thickness of the walls. Beneath the modern steps are found some cells with lateral niches; in the one on the left of the staircase the French consuls were imprisoned in the great revolution. The Sarcophagus of black and white granite, now in the Museo Pio Clementino, together with the busts of Hadrian, very probably once occupied this chamber. We must not, however, omit to mention that the large basin of porphyry, which serves for the baptismal font in St. Peter's, and the porphyry urn which was taken from the tomb of Pope Innocent II., and several objects of equal value, all came out of the mausoleum. So that if we consider its marble-lined walls, both inside and out, the mosaics of the floors. the beautiful columns which encircled its peristyles, the exquisitely finished statues which adorned the upper stories, the bronze figures which ornamented the basement and surmounted the dome, the alabaster urns and sarcophagi of precious marbles which this treasure house once concealed, it would be difficult to over-rate the magnificence and cost of this gorgeous monument, or to exaggerate the folly of the man who reared it for such a purpose. But the imperial architect little dreamed the purpose to which posterity would put his proud sepulchre, nor to what strange vicissitudes he should be indebted for the perpetuating of his name and the celebrity of his grave.

The history of this monument does, in fact, become a history of Rome itself; and, perhaps, before I proceed to speak of it under the modern appellation of Forte St. Angelo, you may be interested in hearing the vicissitudes through which it has passed. From the time that it was joined to the city walls, A.D. 423, it may be considered no longer as a tomb but as a fortress; and, after being frequently taken by the Goths, and retaken by the soldiers of Justinius it was left in the hands of Narses the Eunuch, in 552, and afterwards transmitted to the Exarchs, who succeeded to power in Italy under the Greek emperors.

In the year 908 this citadel, for so I may now call it, is found in the possession of Albert surnamed the Rich, one of the Counts of Etruria. This prince was admitted to a share of the fortress, by a Roman lady, Theodora, more illustrious for her extraction and power than for her chastity. Her daughter Marozia, more beautiful than her mother, but not more modest, kept the citadel as a place of security for her guilt, and at length she celebrated her nuptials in it with Hugo, called King of Italy, and she gave him up the whole for a dowry. It passed through several members of this family, in succession, until it reached Pope John XII., and then it was for the first time possessed by the Bishops of Rome, A.D. 956. They were masters of it for about twenty-seven years, until it was seized by Crescentius, upon the pretext of defending his consulship. He made entrenchments and outworks to it, in order to defend himself against the Emperor Otho III., who came to espouse the cause of the pope; and after a protracted quarrel of eleven years, it was finally recovered for Gregory V. It continued for a long time after to be called the Tower or Castrum of Crescentius.

During the succeeding ages, and in the time of the troubles which drove the popes to Avignon, and comprising the career of Rienzi, last of the Romans, the fortress held a conspicuous place in history. But, on the return of the popes to Rome, 1376, it fell into the hands of the French cardinals. Through those dark ages it was suffered to fall into decay, until Boniface IX. renewed the fortifications, after the designs of Nicollo de Pietro Aretino. After this it was taken by Ladislaus, king of Naples, but was again restored to Pope Martin V., 1431. But the first important additions of modern times were made by the famous or infamous Borgia Alexander VI; he raised the round tower higher, and erected a bulwark of travertine stone between it and the bridge, almost as we see it in the present day. He also constructed the covered gallery, which communicates with the Vatican, about 3,000 feet in length. The arches under the gallery were made by Pius IV., and it was roofed by Urban VIII. Borgia just finished his work in time for his own personal security. On new year's day, 1495, the king of France (Charles VIII.) with his army, entered Rome by the Porta del Popolo, while Ferdinand king of Naples left it by the Porta St. Sebastiano. The pope, says Guicciardini, "*pieno d' incredibile timore e ansietà*," took refuge in the Forte St. Angelo, accompanied by Cardinals Orsini and Caraffà. Alexander VI. refused to give up the forte to the French, in 1495, but the Pope Borgia sent four cardinals to treat with the French monarch, and succeeded in effecting a brotherly alliance. The pope of 1848 sent three cardinals to treat with a French general, and as it appears with equal success, for the Forte St. Angelo remains in the hands of the pope. The similarity which exists between those transactions, separated by a space of four centuries and a half, is most striking. :

Pius IV. was the next pope whose works are worthy of noticef they were not confined to the fortress, but he enclosed the whole o the Vatican and brought his walls down to the Tiber, at the Porta St. Spirito, enclosing the old walls of the Leonine city. Finally, Urban VIII., 1644, completed the walls on the Trastevere, as we now see them, by drawing the line from the walls of Pius IV., and along the top of the Janiculum, and bringing them down to the river at the Porta Portese. The gate of St. Pancrazio and the bastions on each side, rendered so celebrated by the siege of 1849, were all the work of Pope Barberini Urban VIII., and as if anticipating a visit from the old friends of Italy, he appears to have made them much stronger than General Oudinot expected. It was this papal engineer who stripped the Pantheon of its bronze to melt down into cannons for defending the improved fortress of St. Angelo. I have purposely omitted all allusion to the assault of Rome by the Connetable Bourbon, and the bombardment of the Forte St. Angelo, with all the adventures of Benvenuto Cellini in 1527, and when Clement VII. (Medici) took refuge in the fortress.

But having seen this fortress become the occasional residence of popes and cardinals since the revival of the arts, we shall naturally conclude that those dignified persons, who have no antipathy to luxury out of Lent, would not be lodged in rude sepulchral chambers nor shut themselves up within walls of peperine stone or naked brickwork. It will be some refreshment to your eyes, after I have so long wearied your ear, to turn from the heavy walls of a fortification to the decorations of the habitable rooms within, as drawn by the able pencil of M. Grüner. In a saloon in front, which communicates with the balcony facing the bridge, you have some pictures of Pierino Buonaccorsi, called Del Paga, a scholar of Raffaelle; and in the balcony opposite are to be seen some of the designs of Girolamo Siccendante da Sermoneta. But these are nothing compared with the beautiful arabesques which adorn the ceilings of some of the other rooms. I shall not attempt any description of those, because we are favoured this evening with the loan of those exquisite drawings to which I have already alluded. You will remark, as they are passed round the table, the ceiling from which Cardinal Caraffà was, I will not say hung, but suspended; the hook, I believe, still remains in the rosette as a memorial of the deed.

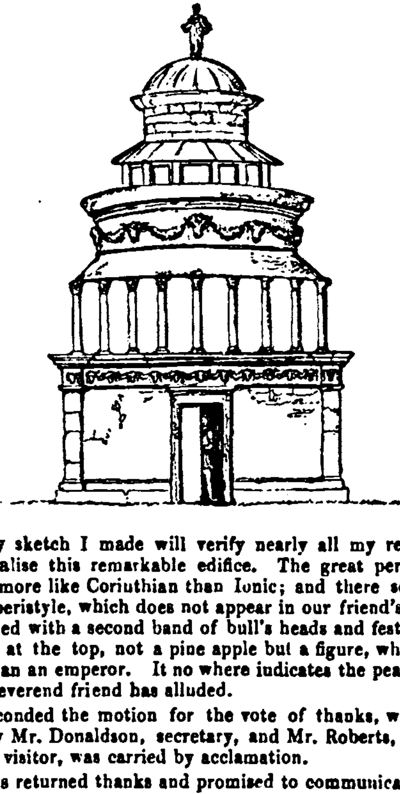
It does not appear in examining the specimen presented to us this evening, that the popes were partial to sacred subjects, or that they thought to reform their state prisoners by representations of heavenly things. Nymphs, Satyrs, Venuses, and Cupids go round together in the mystic dance, and if Christian theology was supposed to have its place at the St. Peter's end of the Borgia corridor, heathen mythology might be very properly imprisoned in the fortress at Rome. I leave you to exercise your own skill upon the mythology, which is couched under griffins bestrode by Cupids, and Mars admitted into the dressing room of Venus. But I particularly propose to your admiration the paintings in a corridor of the Forte St. Angelo, that is in the modern part, by Giulio Romano, as they are rendered by the masterly hand of M. Grüner.

This state prison has always been guarded with great jealousy, and few have ever been known to tell its secrets. Even the artist whose object is known, is admitted with caution; and the antiquary, when he attempts to span and measure, is considered an engineer in disguise. This rigour has been still greater since the recent revolution, and the *entrée* has been next to impossible. The persevering friends of Dr. Achilli, however, did obtain admission, but they do not appear to have seen either Nymphs or Cupids. This is a description which MM. Meymeer and Tonna give of their visit to the interior of the forte on Sunday, 25th November, 1849: "We first crossed a drawbridge, spanning the first or outer ditch, which encircles the bastioned enciente. We walked quite round this; on each of the four bastions a gun is mounted, bearing the pontifical arms: from the height of this wall (which commands to the south and west a view of Rome, and of the Trastevere, and to the north and east the Campagna), we looked with much interest on the prisoners, all dressed in military clothing, who were walking in the deep and damp ditch, which separates the enciente from the immense tower. The base of this latter is of ancient construction. We then crossed another drawbridge which spans this (the second) ditch, and we found ourselves at the entrance of a staircase or sloping path, which crosses in a straight line the whole width of the tower. It was dimly lighted and intersected in four places as we ascended, by traps and drawbridges, each of which would afford successive positions of defence against a party forcing its way from without. On reaching the top we turned to the left, and arrived at an iron gate guarded by French soldiers. They, seeing the unconcerned manner in which we walked up, concluded that we had a pass, unlocked the gate, and admitted us to a platform or court, locking the gate and removing the key after we had passed. Above this court, again, rise the upper buildings of the castle, in which the more important political prisoners are kept, and amongst them our friend. Further than this we could not go. Again the ponderous grating was unlocked, and we retraced our steps down the long and gloomy staircase, and finding that the commandant had not arrived, we left the fortress with a depression of spirit which we could not shake off for the rest of the day. In many parts of the castle we saw inscribed on the walls the name of Alexander VI., the infamous Borgia, and particularly an immense inscription over the gateway of the tower"—

"Alexander VI., Pont. Max. Restoravit, Anno. Sal. 1495."

Such is the most recent intelligence I can give you of the present internal aspect of this remarkable monument, but the prisoner alluded to in the above description having recently escaped, is at this time in London. I should be afraid to trust myself with a beginning of reflections upon the subject I have now finished, for I should be sure in that case to end with a sermon. I will only remark, that however our curiosity may be excited by the stupendous works of antiquity, and however our taste may be gratified by the enchanting powers of art, nothing really interests, either in history or description, but that which was founded for the benefit of mankind, and carried on through ages by the virtue of benevolence. Time is said by our poet to be a beautifier of the dead; but he has not traced a line of loveliness upon the ashes of the selfish emperor, who reared this tomb for his own vanity. Time is said to be the adorner of the ruin; but time has but added deformity to the splendid mausoleum. It is some consolation to know that "glory, built on selfish principles, is shame and guilt;" and it may be a moral lesson not unworthy of the artist and of him who builds for posterity, to learn that whatever in the way of monumental grandeur is not associated with virtuous sentiments, or, as I should say, with morality and religion, will hand down no name to posterity with the reverence and respect, which the architect and the artist, not less than the statesman and philosopher, may lawfully seek to deserve.

The Chairman (Mr. Sydney Smirke, V.P.) said, we have been so often charmed, instructed, and elevated by our reverend friend's eloquence, that I really am at a loss to shape into a new form the expression of our thanks. Our heartiest gratitude is indeed due to him for the great treat he has given us this evening. It is quite clear that Mr. Burgess's treasures of research, as well as of memory, are inexhaustible; for I had hoped that he had not heard of the illustration which the bronze door of St. Peter's offers of this monument. That, however, has not escaped him. I am happy in being able to show a slight memorandum of that *bas relief*, a copy of a hasty sketch which I made when I was in Rome. I do not remember whether the date Mr. Burgess mentioued is perfectly authenticated; I should have thought, from the very barbarous character of this relief, that it was of an earlier date. I dare say, however that he is right; but one would have thought, that in Rome a work upon an imperishable material, on the principal door of the greatest building in Christendom, would have been better drawn.



The very hasty sketch I made will verify nearly all my reverend friend's attempts to realise this remarkable edifice. The great peristyle columns, however, look more like Corinthian than Ionic; and there seems to be an attic over the peristyle, which does not appear in our friend's drawings, apparently enriched with a second band of bull's heads and festoons. The *bas relief* exhibits at the top, not a pine apple but a figure, which looks like a cupid rather than an emperor. It no where indicates the peacocks and bulls to which our reverend friend has alluded.

Mr. Tite seconded the motion for the vote of thanks, which after some observations by Mr. Donaldson, secretary, and Mr. Roberts, fellow, as also by Mr. Lloyd, visitor, was carried by acclamation.

Mr. Burgess returned thanks and promised to communicate a paper next session, if spared another year, upon the Viæ Romanæ, as compared with modern railroads, and with reference to the vastness and magnificence of each.

Stoney Stratford.—A Roman villa has been discovered in the parish of Pauler's Pury, near Stoney Stratford, on the property of the Duke of Grafton, and near the course of the Roman road, Stratford being the Lactodorum of the Romans. Already a fine tesselated pavement has been brought to light.

SCULPTURES AND ARCHITECTURE OF ASSYRIA.

Some Remarks on the Style of Ornamentation prevalent in the Assyrian Sculptures recently discovered by Dr. Layard, *and on some Peculiarities of Assyrian Architecture, as exhibited thereon.* By Sydney Smirke, Esq., V.P.—(Paper read at the Royal Institute of British Architects, March 18th.)

In submitting for the examination of the meeting some casts which I have, through the kindness of the Trustees of the British Museum, been permitted to have made of some small portions of the Assyrian sculpture recently deposited in the British Museum, I beg to detain you, for a few minutes only, with some remarks upon the style of ornamentation which appears to prevail in these very curious works of ancient art.

The love of ornament which distinguishes all eastern nations at the present day seems to have equally prevailed among the ancient people of whom representations are now, for the first time, brought before us in these interesting remains. Very few female figures occur, but scarcely a male figure is represented, whether priest or warrior, without large ear-rings, and most of them have necklaces, bracelets, and armlets. It is to be remarked, however, that not a single case occurs, amidst all this display of personal jewellery, of a finger-ring; the entire absence of this ornament in sculpture, wherein details of this nature are so elaborately and carefully attended to, leads to the unavoidable conclusion that the finger-ring was an ornament unknown to the Assyrians. I am not about to digress into any question of the antiquity of finger-rings, an enquiry for which I am not competent and which would be here inappropriate I will only take occasion to say, that much of learned disquisition as there has been on this subject, the question remains to be answered. I think there has been much confusion produced by the vague use of the word *ring*, and the too ready assumption that when rings are named, *finger*-rings are intended. Signet-rings may have been, and were, worn suspended from the neck, or attached to a chain. There are in the Book of Esther, and in Jeremiah, very clear allusions to finger-rings, but the earliest classical authority that I am at present aware of (and for this I am indebted to my friend, Mr. Birch), is Pausanias, who says that he saw on the walls of a temple at Delphi a painting by Polygnotus of Phocis, represented with a ring on his left hand. Polygnotus flourished about 422 years before Christ. It is, however, very remarkable, if it be true, that there is no example known of a Greek statue with a ring on the hand.

Reverting to the sculpture under consideration, I find their apparel almost always richly fringed; with wide borders ornamented with figures of men, animals, and foliage. The caparison of their horses is most gorgeous; every strap of their head and body housings is enriched; to the chariot horses there is usually seen attached, apparently either to the extremity of the pole, or to the trappings of the neck, and to the front of the chariot itself, a long fish-shaped piece of drapery, fringed and embroidered. Dr. Layard is at a loss to designate this object. Perhaps, "the precious clothes for chariots," alluded to by Ezekiel as being obtained by the people of Tyre from Dedan, may have reference to this singular piece of horse-furniture.

The same love of ornament above alluded to is apparent in their pavilions, of which there are specimens in this sculpture; also in the fashion of their armour; the hilts, handles, and sheath-ends of the swords; their knife handles, their slings, and their quivers. There are in the British Museum some lions' feet of bronze, apparently belonging to furniture, which formed part of Dr. Layard's collection at Nimrood, and are equal to Greek workmanship in execution.

The style of art which characterises all these ornaments offers us a subject of curious enquiry. What relation does it bear to other styles? To what extent is it original? And to what extent does it appear to have influenced other succeeding styles known to us? Major Rawlinson, who has fortunately succeeded in mastering to a great extent the difficulties that have hitherto hidden from us the knowledge handed down in the strange characters that cover these and other remains, entertains no doubt that the earlier ruins from whence these sculptures have been derived, bear the extraordinary date of twelve or thirteen centuries before the Christian era. This sculpture, therefore, is probably as old as most of the Egyptian antiquities we possess; yet the style of the ornaments, although certainly partaking somewhat of Egyptian character, is in many respects widely different from it. The borders of the linen wrought in successive stripes, and those stripes subdivided into a succession of squares, is certainly an Egyptian peculiarity, prevalent in this Assyrian costume. Indeed the people of the two countries, although widely separated from each other, may most probably have interchanged commodities, and goods of so portable a kind as bales of linen may well have found their way from Egypt to Assyria. We have the incontestible and contemporary evidence of Ezekiel, that Egypt furnished "fine linen with embroidered work" to the merchants of Tyre, who it may be presumed supplied the markets of Nineveh. There seems therefore no reason to be surprised at finding Egyptian patterns worked on the dresses of the personages so carefully represented on the walls of the Ninevite palaces, nor can any conclusion be safely drawn from that circumstance that there was any identity of design between the works of the artists of those two countries. It may however be here observed that in the trappings of their horses there is a somewhat strong resemblance between these examples and those afforded by the Egyptian paintings in the British Museum.*

The Honeysuckle ornament so abundantly used in the sculpture before us is, I believe, nowhere seen in early Egyptian work. Nor are there any traces of resemblance between Assyrian and Egyptian design in the beautifully and freely drawn figures of animals so profusely introduced into their work by Assyrian artists. We seek in vain here for those stiff and formal and very peculiar ornaments round the neck, consisting of a continued repetition of strokes of the pencil which we see constantly recurring in Egyptian work, especially on the mummy cases. The Assyrian artist seems to have completely relieved himself from the rigid conventional manner of the Egyptian, and to have acquired considerable facility and freedom of execution: examine the slightly-etched figures of winged bulls and other animals pervading the dresses of almost all the larger figures on this sculpture, and we find them drawn, or rather sketched, in a style that would do credit to the best artists of the present day; and when we consider the enormous extent to which this mode of decorating the walls of their buildings prevailed, not only at Nineveh, but at other buried cities which have been recently explored in the same country, it seems fair to presume that the trifling and very subordinate details to which I have been adverting must have been the work of common and ordinary artizans.

Let us now compare the ornaments under review with the more familiar forms of Greek art: and here I think we find so strong an analogy, and in some cases such a striking resemblance, as to force upon us the conclusion, that the artists of Greece derived far more of their art from the banks of the Tigris and Euphrates than from the banks of the Nile; and Egypt must, I think, relinquish a large portion of the honour that has been so long accorded to her of having been the mother of Greek art. The honeysuckle ornament, already alluded to as occurring abundantly in this sculpture, is both in form and treatment almost purely Greek.

The Guilloche scroll, so characteristic a Greek ornament, occurs very accurately chased on the scabbard of one of the swords of the Assyrian warriors. An ornament much resembling (although not identical with) the labyrinth fret, also appears etched as an ornament on a dress. The classical enrichment, commonly called the bead-and-reel, is here of very common occurrence. The running ornament of animals and foliage grouped together, constantly occurring in this costume, is a perfectly classical feature.

I purposely confine myself to the style of ornamentation visible in these works, and forbear to enter into any similar comparison between Assyrian and Greek sculpture in its higher qualities, for such an enquiry properly falls within the province of the sculptor; but were I to do so, I apprehend we should arrive at the same result. It needs not the professional eye of a sculptor to see in the attitudes and drapery of the figures a regular and progressive, although perhaps a slow, development of art, from these marbles through those of Asia Minor and Sicily down to the works of Phidias.

Whilst inviting attention to the germ and gradual growth of that beautiful system of decoration which has been handed down to us by the Greek artists, and has been the object of imitation during succeeding ages, not excluding even the mediæval age, I am tempted to suggest whether much of it, perhaps almost the whole of it, may not have had its origin in the use of sacred emblems or in the representation of sacred objects.

The Bull was deified in the earliest ages, and we see it carved in profuse variety as an ornament on these marbles. It occurs abundantly in the sculpture of Asia Minor, and in classic art became a favourite ornament. The Lion, also, furnishes us with another very familiar instance of an animal deified by the Egyptians, and introduced by the artist in every variety of form as an ornament. The honeysuckle which, under the wonderful influence of Greek taste, became so beautiful and so universal an ornament, is here found many centuries before the birth of Greek art as representing the sacred tree before which the Assyrian priest is performing his religious rites. The fir cone, which plays so prominent a part in classical decorative sculpture, is in these marbles almost always held as an offering in the hand of the priest. The lotus is another familiar instance. We find it first the object of worship in Egypt, but afterwards converted into one of the most beautiful of all the forms of antique ornament.

The Rosette, or Patera, is perhaps one of the most universal ornaments in the whole range of art. It occurs in the paintings of the Egyptians, and is carved on Hindoo sculpture; it was embroidered on the garments of the Assyrians, and ornamented their armlets, bracelets, and even their whip-handles. Nor on the sculptured remains of Persepolis is it wanting. The rosette is painted on the fictile vases of all ages, from the earliest to the latest, and has ever been one of the most common of all the ornaments of architecture. May I not venture to claim for this form, also, a sacred origin? The winged circle was the emblem of the deity in Egypt, Assyria, and Babylonia. It occurs frequently in the marbles before us, and is usually filled in with what has the appearance of a rosette; but when the circle is large, we find the inserted figure to have a star-like form, or a radiation of tapering flames: may this not be supposed to typify the sun, the great and earliest object of idolatry? Is it not at least a plausible hypothesis that this figure, whether it be a conventional representation of the sun, or a star, may in the course of time have assumed in the hands of the artificer, the varied and beautiful ornament with which we are so familiar?

I may here take occasion to advert to that mystical figure of which Dr. Layard gives us a representation in his work, and of which we have examples in the marbles before us, as well as in those of Persepolis. It consists of a circular figure like a wheel, with rays emanating from the centre; and from this wheel issues the upper part of a man, terminating from the loins downwards in flames; and flames issue from the sides of the wheel, left and right, assuming the general appearance of wings. The general correspondence of this figure with those of the cherubim and the wheels, as described in the visions of Ezekiel (chap. i. and viii.), is too striking to escape observation. It is unquestionably a sacred and supernatural form, occurring, as Dr. Layard observes, usually over the head of a victorious monarch, and may represent a tutelary divinity or an angel. I have already stated that I confine my remarks, on the present occasion to the ornamental details, but the whole sculptures well deserve far more attention than they have even yet attracted, although I am not insensible of the great value of the learned disquisitions published by Dr. Layard. The glimpses which these interesting monuments afford of a primeval architecture are to us especially interesting.

Dr. Layard has remarked with truth on the very wide difference existing between the style of Assyrian architecture developed in these remains, and the architecture of Egypt. There appears here to have been an almost total absence of columns. Dr. Layard gives us a representation of one instance occurring in a *bas relief* found in the ruins of Khorsabad, which he presumes to be of later date than those of Nimrood; and in the slabs in the British Museum one example occurs, wherein three pillars are introduced, but of proportions so slender as to lead to the presumption that they were of wood; a supposition the more probable, as they appear to support, not a horizontal entablature, but the frame-work of a kind of tent: it is worthy of remark, that these pillars have as their capital the horns of the goat so arranged as to suggest at once the Ionic capital, and the Khorsabad example is also of this type.

The absence of columns may possibly be due, in great measure, to the flat, alluvial character of the district between the Tigris and Euphrates, which furnished the soft alabaster of which these slabs are formed, but no hard building stone suitable for columnar architecture. Rooms, however, 35 feet and 40 feet wide, such as occur in the palaces explored by Dr. Layard, would not have been roofed over without a greater degree of constructive skill in carpentry than we have any reason to suppose was possessed in these early ages. Perhaps, therefore, the horizontal beams of which the roof was formed may have been supported by wooden pillars which are now perished, or which may have been burnt when these temples were sacked, a fate which most of them have probably undergone. That pillars were used to support the roof-timbers is the more probable, as it appears that the apartments were lighted from above by apertures in the roof, which would interrupt the

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* An architect from Vienna informs the author of this paper that the caparisons of these Assyrian horses strongly remind him of those now used in the southern provinces of the Austrian empire, and the adjacent parts of Turkey.

continuity of the timbers, and render intermediate supports absolutely necessary. It may be asked, why assume that the Assyrians were ignorant of framed trusses, by which the widest spans might be roofed over without the assistance of intermediate supports? We cannot prove the non-existence of trusses, but we certainly have no evidence that such artificial contrivances are of this remote date. We see no indication whatever of pitched roofs in any of the sculptures before us, nor, I believe, at all in Egyptian architecture. Even in the Lycian examples we do not find, until we come down to the Greek period of art, any example of a pediment, which is but the gable end of a pitched roof. These Assyrian palaces, then had, I presume, flat terraced roofs, as we know the Egyptian buildings had: it is the present fashion of the east, and that it has ever been so there is abundant proof in the Scriptures. It was a law of the Jews that no roof should be built without a parapet, so that those walking thereon might be rendered safe. In the sculpture before us are various representations of small domestic buildings; they have no sloping roofs, but are rounded at top as if formed of slight timbers bent round, which were probably wattled over and covered with mud like the wigwams of the present day. The pavilion, also, to which I have already adverted, appears to have had its covering stretched over similarly bent timbers. It does not seem improbable that the curved and pointed roofs of the Lycian tombs own a similar type, and are a marble version of a roof of bent timbers.

Dr. Layard discovered no indications of windows in any of his excavations; but that windows were used in Assyrian architecture is proved by the representation of them occurring in many of the slabs: nor can we imagine any other mode of gaining daylight in the lower rooms when buildings were of several stories in height, which, by these *bas reliefs*, appears to have been the case. These windows are square-headed, generally, and have the peculiarity of a double or rebated external reveal, by which means, like the splay in Gothic architecture, additional light was gained, the actual apertures being narrow. This square sinking in the jambs of a window are, I believe, without a parallel in Egyptian architecture, and is not seen in purely Greek buildings; but it is singular that this is a feature pervading the very ancient tombs of Asia Minor, recently made known to us; many instances of it occur in the Xanthian marbles at the British Museum. Whatever may be the date of the marbles from Xanthus, they certainly appear to be a very remarkable link between Greek art and some other very different, pre-existing style.

The occurrence of circular-headed openings in the fortified buildings of Assyria, as plainly represented on these *bas reliefs*, dissipates at once all ideas formerly entertained of the comparatively recent discovery of the principle of construction. Dr. Layard mentions a brick vaulted chamber which he brought to light among the ruins of Nimrood, and other similar discoveries are reported to have been still more recently made by him. It seems a reasonable conjecture that the Arch may have been first used in an alluvial country like that of Assyria, where abundance of bricks were made, and where the difficulty of transporting from remote distances large blocks of stone, fit to form a straight lintel over a wide bearing, would render the substitution of an arch turned with bricks, or small stones, peculiarly convenient.

We may notice that tubular drain tiles were used in removing the rain-water that fell through the openings in the roofs, on to the pavements of the several apartments. That so obvious and simple a contrivance should have been resorted to by a people possessing great dexterity in the fabrication of fictile ware, and living in a district where the common soil of the country furnished the materials to their hand, seems so natural as scarcely to justify more than a passing remark; yet, is it not curious, that now, in the nineteenth century, and in England, a tubular draining tile is one of the most recent of novelties?

A thin stratum of bitumen is mentioned by Dr. Layard as occurring under all the floors, and passing, as he observed, under these sculptured slabs of alabaster with which the inner face of the walls was lined. He was unable to account for this, but the architect will at once perceive that this was a precaution taken to prevent the damp from arising from the earth under the pavement, and destroying the paintings, and endangering eventually the alabaster itself.

Reverting again to the representations of Assyrian Castles on the slabs before us, I must not omit to call your attention to the crenellated parapets having battlements generally pointed or notched, as if to facilitate the use of the bow and arrow. Here also we find an analagous case in the friezes of the Lycian temple, discovered by Sir Charles Fellowes, and now deposited in our Museum. Castles are there represented with embattled parapets very similar to these in Assyria, and not unlike examples still subsisting in the East.

It has long been a subject of speculation what style of architecture characterised the first temple of Jerusalem. I think that it may be not unreasonably presumed, that the magnificent ruins now brought to light, after an interment of two or three thousand years, afford us a far better clue than any we have ever yet possessed; a much more intimate connexion existed, both geographically and politically, between the inhabitants of Palestine and the people of Assyria and Babylonia, than with the Egyptians, from whom they were separated by the Arabian desert. Perhaps, too, the marbles under discussion will be admitted as evidence of an earlier civilisation of art among the former people, and therefore of their greater influence in matters of taste. We have indeed the evidence of the Scriptures that Solomon sought his artists—his "cunning workmen"—in the region north of Judea; Hiram of Tyre was his worker in metals, and his best carpenters were Sidonians.

With how deep an interest, then, these considerations seem to invest the sculptures from Nimrood! When, to use the eloquent words of Dr. Layard, we reflect that "Before these wonderful forms, Ezekiel, Jonah, and others of the Prophets stood, and Senacherib bowed; that even the Patriarch Abraham himself may possibly have looked upon them:" that works of such extraordinary interest and value should, after the lapse of thousands of years, have found their place in our National Repository, is indeed a matter of just pride and congratulation, and I cannot forbear to express a confident hope that no exertion may be wanting on the part of our rulers, and of the nation generally, to second the indefatigable zeal of our countryman in securing for us a still farther accession to this most important collection.

In conclusion, Mr. Smirke referred to the recent accounts from Nineveh, as being provokingly vague and meagre. There had been found, it would appear, a most miscellaneous collection of rich armour, antique vessels, costly apparel, and other treasures, put together in a manner perfectly perplexing. An ingenious pupil of his, Mr. Cates, had, however, drawn his attention to a passage in Diodorus Siculus, which would perhaps help to explain so otherwise unaccountable a circumstance. Sardanapalus, as they all knew, when his danger was imminent, and the Median enemy in possession of his city, owing to a sudden irruption of the river breaking down twenty stadia of the walls, collected together all his vestments and treasures, and formed of them a grand funereal pile. On the top he placed his concubines, his eunuchs, and himself; and, applying the torch, the whole were burnt together. Diodorus relates that one of the eunuchs made his escape, and gave information to Belesys, a Babylonian priest, that under the ruins of the king's palace might be found enormous treasures. The priest went straight to Arbaces, who, in the midst of his triumph, was distributing rewards to his satraps, and reminding the monarch that he had predicted the fall of Nineveh, said that in the midst of the battle he had vowed a vow to Belus, that if the Babylonians were victorious, he would convey the ruins of the royal palace to Babylon, and erect there a temple to that god, which should at once serve as a landmark to those who navigated the river that ran by that great city, and be a monument of the destruction of Nineveh. The Median king, who was described by Diodorus as possessing a noble and generous disposition, granted to Belesys all the ruins of the royal palace for this purpose. The priest then, with the help of the eunuch, removed a greater part of the treasure; but the fraud was discovered, and he was condemned to death. The operations of the priest, so far as the treasures were concerned, were surreptitious, and of course the investigation of the ruins could not have been so complete as if it had been conducted openly and deliberately, and that would seem to account for the incongruous heap of valuables discovered by Dr. Layard. Thus, if the eunuch had not had so natural a distaste to be one of the party in the royal *auto-da-fe*, Dr. Layard might have been by this time in possession of all the treasures of Sardanapalus.

Remarks made at the Meeting after the Reading of the foregoing Paper.

Mr. **Bellamy** (the Chairman.)—Our best thanks are due to Mr. Smirke for his interesting paper on this highly interesting subject. I may mention, as an addition to the paper, that I have noticed in these sculptures the apparent existence of folding doors. I cannot help expressing a wish that these excellent sculptures may be speedily removed from the cellar which they at present occupy, to a better position, where they may be seen to greater advantage.

Mr. **Donaldson**.—There cannot be a doubt but that Dr. Layard has at Nimrood brought to light a class of architecture or style of art, which prevailed not only on the banks of the Tigris, but also obtained through the extensive region of country called Assyria, which included Media and Persia. I have here a volume of the 'Universal History,' published in 1747, which contains copies of Le Brun's representations of Persepolis. These engravings show a great number of columns, and a perfect identity, not only of style, but of the objects represented in the bas-reliefs—winged bulls and lions, crowned with a sort of cap, divinities, &c.—drawn more than one hundred years ago. There are also bas-reliefs with long lines of personages in procession, exactly in the same style of costume as those to which Mr. Smirke has drawn our attention. The figure, which he supposes to be a tutelary divinity, is likewise here represented as being common on the tombs in the neighbourhood of Persepolis, exactly in the same way that they are represented in Egyptian antiquities. The kings of Persia used to reside alternately, according to the season of the year, at Babylon, at Susa, at Ecbatana, and at Persepolis; at all of which places the same character of style and art would prevail. I am therefore inclined to the supposition, that the architectural remains now brought under our notice form but one of a class, which was spread over the whole country; a fact which I think would be more obvious, if we had equally excellent illustrations of the ruins of Persepolis, as of those now before us. The winged lions from Nineveh, now in the British Museum, are crowned with a sort of cap commonly found upon the sphinxes in Egyptian remains; and it is remarkable that the bulls from Nineveh agree exactly in size with those at Persepolis, both being about 22 feet long and 14 feet high. That is another sign of identity, and I conceive the material will furnish another. These remains are said to be of alabaster, and that was a material frequently used in Egypt, as witness the sarcophagus in Sir John Soane's Museum; and, indeed, throughout our own Gothic period. For architectural ornament, or sculptural devices and figures, the use of alabaster has been extensive in all periods of art. I cannot agree with our friend, that Israel had more to do with Assyria than with Egypt; as the latter is mentioned much more frequently than the former in Holy Scripture; and, it will be remembered, the aid of the Egyptians was called in to resist the Assyrians, who in the end actually carried the Israelites away captives. At an earlier period, too, Solomon married the daughter of Pharoah. There was, besides, a greater affinity in the art of Israel to that of Egypt, rather than to that of Assyria. There must, too, have been a great enmity between the Persians and the Egyptians, for Cambyses invaded the latter, destroyed the temples of Thebes, slew the god Apis, and dishonoured the tomb of Amasis, king of Egypt; and, therefore, the Israelites could not very well have been friendly with both. Dr. Layard says it is probable that Abraham saw these sculptures, but I doubt that the Holy Scriptures justify this supposition. We know that there were pyramids in Egypt one hundred years before the death of Noah; and it has always been the practice to assign a higher antiquity to Egyptian architecture than to Assyrian. I am myself of opinion, that there is in these sculptures signs of a depreciation from the simple principles of an incipient and rising art; and that it is rather a degraded phase of Egyptian art, than a new and original class. In conclusion, Mr. Donaldson proposed a vote of thanks to Mr. Smirke, and also to Mr. Murray, for the illustrations with which he had favoured the Institute.

Mr. Smirke remarked that the representations of the Persepolitan sculpture were very imperfect. The best were those of Sir Robert Porter; but even he was not a very careful draughtsman. He hoped the time would soon come when they may be as well known as those of Assyria. With regard to the connection of Israel with the countries of Egypt and Assyria, it must not be forgotten, that although Solomon married Pharoah's daughter, he sought his "cunning workmen" and the materials for his great architectural works in the opposite direction. He begged to repeat his decided conviction that the Assyrian marbles bear a much more marked affinity with the succeeding Greek style of art than that of Egypt.

The Chairman thought he could detect a knowledge of perspective in Assyrian architecture; and in some instances there were indications which would lead to a supposition that they had also a knowledge of the principle of the arch.

Mr. C. H. Smith said these marbles were said to be alabaster, but that conveyed a wrong impression, as he believed they were not alabaster proper or sulphate of lime. He had slightly examined the Assyrian marbles, and believed them to be carbonate of lime. Dr. Buckland had, he knew, said they were alabaster, but the Doctor had told him that he had not examined them closely.

The Chairman said that he believed one was a conglomerate or freestone.

Mr. Ferguson said that the members did not seem to be aware that the French had sent to Persepolis, and had copied all the sculptures discovered there to a very large scale and with great accuracy. The drawings were much better, he should say, than those now exhibited of Nimrood, and that they gave more details, and were more complete in every way. The last letters from Dr. Layard announced that he had discovered the throne of the King, upon which there was not the slightest trace of fire. It was composed principally of ivory with gold ornaments. There were traces of cloth trappings; and the gold thread with which it was sewn and embroidered still remained. This throne had been found in the same ruin as that which contained the miscellaneous collection of valuables already alluded to, but not in the same chamber. The condition of the articles discovered proved indisputably that that palace had never been destroyed by fire. Major Rawlinson had, however, satisfactorily determined that Nimrood was not Nineveh; that city had not yet been excavated. The name of Jonah having been found at the onset on the ruins, no further excavations were allowed by the Mahommedans on that spot. The attachment of the horses to the cars in these sculptures, which seemed to occasion some difficulty, was easily explainable, inasmuch as it was in common use in India to this day. The pole comes from the axle, and a sort of platform is carried on till it meets the yoke. That is always covered in India with red cloth, ornamented in the same way as appears in the sculptures. The upper part is a platform on which the driver can sit. In answer to the remarks made upon the honeysuckle ornament, it appeared to him quite clear, that the Ionic was derived by the Greeks from Asia, and the Doric from Egypt. Thus in these marbles there was no trace of Doric, but everywhere traces of Ionic, for in Egypt the Doric was found all the way from Nubia down to the caves of Memphis. His opinion was confirmed by that of all the greatest authorities.

Mr. Scoles remembered during the whole course of the Nile, from the second cataract downwards, but two instances of anything like Doric columns, and they were simply fluted cylindrical shafts without proper capitals.

Mr. Ferguson.—Yes, they have the square abacus.

Mr. Scoles wished to ask his friend Mr. Smirke, whether he considered this an architecture *sui generis*, and if not, whence derived ?

Mr. Smirke.—If not indigenous, it is impossible to say whence it was derived, for we are unacquainted with any earlier style of architecture.

Mr. Fowler said that the bull taken in the Burmese war was engraved with ornaments, just as might have been supposed to have been executedin the best days of Greek art. There was upon that the honeysuckle ornament found on these Assyrian remains.

Mr. H. B. Garling asked why Mr. Smirke supposed these details were not executed by skilled artists?

Mr. Smirke.—Because they are so numerous that a master hand could not have been engaged upon them all. They are sketched with the utmost profusion over the whole of these sculptured remains.

TOWERS AND SPIRES OF THE MEDIÆVAL PERIOD.

Some Observations on Towers and Spires of Churches of the Mediæval Period. By John Britton, F.S.A.—(Paper read at the Royal Institute of British Architects, April 8th.)

Mr. Britton addressed the meeting nearly as follows:—"Mr. President and Gentlemen,—I am induced to appear before you on the present occasion, most probably for the last time, to call your attention to the interesting series of drawings now exhibited, which have been made by Mr. Wickes, architect at Leicester, who has devoted much time, skill, and perseverence to a task which he has entailed upon himself, *con amore*. How far he has succeeded in the execution of that task you will be enabled to judge by a cursory inspection of the drawings. Had I not believed that they were worthy of the attention and admiration of this learned and scientific body, I should not have obtruded them on your notice; but satisfied as I am of the interest attached to the subject, and of the accuracy and skill manifested in the drawings; and believing also that the various towers and spires of Great Britain in particular, and of the civilised world in general, are entitled to the diligent study of the architect, and the admiration of the antiquary, I volunteer my weak and humble services in thus introducing a provincial member of the profession to the Royal Institute of British Architects.

Before alluding further to his deliniations, I gladly avail myself of the present opportunity to acknowledge and thank this society for the honour and compliment which they paid me at its formation, by electing me as the first honorary member. Though it has been to me a source of pride and pleasure to receive similar compliments from several other societies devoted to architecture and archæology, I must own that I never derived so much gratification from any of them, as from this proof of the esteem of the architects of London, with many of whom I had been intimately acquainted for years. To have secured the approval of such a body of artists, and to receive from them a voluntary testimony of their regard by that election, surprised and delighted me. The only thing I have regretted has been, as it still is, my inability to render that assistance to the society which I have always wished to do, but which other pressing demands on my time have prevented. In the progress and prosperity of the Institute I have always felt deeply interested, and therefore hail with much delight the position it has attained—not only in our own, but in foreign countries. May it long continue to prosper, and thereby confer honour on all its members, generally and individually; may it give to English architecture a character and dignity rivalling, not merely that of classical and mediæval antiquity, but of all co-existent nations in the world;—may laudable rivalry—divested of envy and all other bad passions—govern and be diffused through the society;—and may all its councils and proceedings be characterised by liberality of sentiment and action, and by devotion to the credit and welfare of the profession."

Mr. Britton then read part of the following paper which he had prepared for the occasion; but weakness of the organs of the throat, from long illness, rendered him unable to go through the whole.

In the subdivision, and in the distinctive parts of churches, there is not one which more strikingly contra-distinguishes the buildings of the mediæval age from those of the Pagan world, than the Tower, Steeple, and Spire. This marked feature of a churchwas invented by the earliest Christian architects, who in the first place designed and raised a plain, simple, and rude pile, small in size, and devoid of of all ornamentation. In every succeeding age and era they produced changes and improvements in this architectural member; and it is equally evident, that every architect invented something new in form, proportion, and detail, in each and every new tower that was progressively erected. I believe, it may be safely said, that there are not two of these buildings in England precisely alike.

It has been erroneously supposed by writers on mediæval architecture, that the employment of spires, or pyramidal terminations of towers, was a consequence of the introduction of the pointed arch; and that the towers of churches, erected before that important era in the history of architecture, were designed to be perfectly flat at the top. This mistake has arisen from the circumstance, that the most ancient towers have lost their original finish; some being now covered with flat roofs; others having spires, pinnacles, and certain appendages of much later date; scarcely any, indeed, remaining unaltered at the present time. But if we examine the representations of churches in ancient drawings, and on seals,—a species of evidence of the greatest possible value,—we find that spires were very common in the eleventh and twelfth centuries; and even among the Anglo-Saxons long before. The engravings from ancient Saxon MSS., in the works of Strutt, comprise many spires, finished with crosses and weathercocks; and the well-known drawing of Canterbury Cathedral, made by Eadwin the monk before the destruction of the church by fire, in 1174, displays no less than five spires on the church itself, besides some on the out-buildings. Compared with those of the fourteenth and fifteenth centuries these primitive spires were very clumsy; they were square in plan, and either covered with lead, tiles, or shingles; and the loftiest were not more in height than twice the diameter of their base. Two ancient spires of this form remained till the beginning of the present century, on the western towers of the collegiate church of Southwell; and there are still two small ones at the angles of the west front of Bishop's Cleeve church, Gloucestershire. A great improvement was effected in the form of spires, by reducing them to an octangular shape; though the earlier examples of that kind had still a square base, the angles being sloped upwards to the spire. By this alteration, though their height was not actually increased, they had an appearance, when viewed at an angle, of much greater loftiness. There are many stone spires of this kind in Lincolnshire and in the adjacent counties.

Though the builders of stone spires appear to have been cautious of increasing their height, those of timber soon assumed a great altitude with proportionate elegance of form; and were at length made of much less breadth than the towers on which they were built, and with a degree of slenderness never attained in stone. There is a fine timber spire at Long Sutton, Lincolnshire; and one of the earliest stone spires is at Sleaford Church, in the same county.

Stone spires, as well as those of timber, were gradually reduced to a more slender proportion. In the fourteenth century their angles were decorated with crockets; and the pinnacles at the angles of the tower below were frequently connected with the spire by arch or flying buttresses.

The forms, proportions, and details of Towers and Spires were infinitely varied and diversified. They were most usually placed at the western end of churches; and some of the larger and more elaborate edifices,—as York, Lichfield, Canterbury, Lincoln and Wells Cathedrals, have each two towers at the west end, and a third at the centre, or intersection of the nave and transepts. In Lichfield Cathedral each of the three towers is crowned by a lofty and elaborate spire. Exeter Cathedral presents the unique example of a tower at the extremity of each transept.

The Towers of churches are either square, round, or octagonal; the first being the most frequent. Large doorways and windows, buttresses, stringcourses, and other decorations diversify them. In some examples (as at St. Mary's, Cheltenham; Almondbury Church, Gloucestershire; the church at Reculvers, Kent; and many others), the bases of the spires cover the whole upper surface of the tower. Occasionally, indeed, they form projecting eaves; but at a later time the tower was separated from the spire in a marked manner, by a parapet, either plain, embattled, or perforated. The buttresses forming the angles of the tower were terminated by elaborate turrets, or pinnacles, the whole forming a richly ornamented group.

There are numerous towers of all ages *without* spires; and some (as at Ely Cathedral, and the churches of Fotheringay, Northamptonshire, and Boston, Lincolnshire), are terminated with octagonal turrets, or lanterns. At Sutton Benger Church, Wiltshire, is a plain square tower, with a rich embattled parapet. From each angle of the parapet rises a small pinnacle, whilst the *centre* of the face of the tower sustains another, somewhat larger, and of florid decoration, but more diminutive than the ordinary *spire*.

The towers of the Somersetshire churches present many beautiful and interesting characteristics, worthy of the ages of Henries VI. and VII.

It would be irrelevant to the present purpose to advert to the fine and elaborate towers and spires of Continental churches and cathedrals;—those of Antwerp, Strasburg, Freiburg, St. Stephen's, Vienna, and Malines, will readily occur to the memory of the architectural student.

In more remote connection with the subject, the Round Towers of India, of Ireland, and of the eastern counties of England, the Keep, and Bastion Towers of ancient fortresses, as well as the Tower Gate-houses of old English cities, claim a passing allusion; as at a more favourable opportunity they would well repay attentive consideration and lengthened comment.

It cannot fail to be a subject well worthy investigation and illustration, for an architect to inquire into the history, peculiarities, construction, design, and endlessly-varied features of towers and spires, and also to prepare such a series of drawings as would clearly and amply illustrate the progressive improvements made in this department of the architect's professional career.

Actuated by a laudable desire to accomplish a publication of this kind, Mr. Wickes, of Leicester, has visited several of the cathedral, collegiate, and parish churches of England, and made drawings of their interesting towers and spires, which he proposes to have lithographed and published. In a prospectus which that gentleman has issued, he mentions his intended work as "a desideratum in the history of our national architecture." He adds, with equal truth, that "among the many beautiful and striking relics of mediæval art scattered throughout the land, the spires and towers of our churches stand pre-eminent for richness, variety, and elegance, and hence deservedly claim the tribute of our praise and admiration. Reared by the hand of genius, and dedicated by the spirit of piety, these stupendous fabrics,—

> "Point as with silent finger to the sky and stars;"

and after the lapse of centuries remain to bear indisputable evidence to the taste and skill of our ancestral architects. The grandeur of their composition, and the fineness of their outline, their exquisite proportion, richly sculptured ornament, and yet chaste detail, display the astonishing invention and æsthetic ability of their designers; no less than the boldness of construction and scientific arrangement of thrust and counterpoise attest their wonderful skill, and the proficiency to which they had attained in the study of architectural dynamics."

Some of Mr. Wickes's drawings are now exhibited; and should the profession and the public be disposed to patronise his undertaking, he will be enabled to publish a series of illustrations, sufficiently numerous to characterise all the leading varieties of tower architecture in England.

In order to direct the attention of the present meeting more particularly to the subject, I have ventured to offer these few remarks on the leading peculiarities of ancient ecclesiastical towers and spires.

Remarks made at the Meeting after the Reading of the foregoing Paper.

Mr. GODWIN thought the drawings now exhibited beyond all praise. If any proofs were required to refute the assertion of a recent writer, that all parish churches displayed bad architecture, the series of drawings now before the meeting would do that most triumphantly. The towers and spires of England, commencing with the Norman and ending with the early English period, exhibited invariably a wonderful beauty and exactness of proportion, and a marvellous grace of outline. The spires of the latter period he had mentioned, presented a variety of character which was most extraordinary, considering how few were the elements at the command of the architects. They had only the square, the sexagon, and the octagon, and yet there were not two steeples to be found at that period precisely alike; while their outlines had a power and beauty, which completely disproved the assertion, that all the old parish churches of England were bad Gothic. While on this subject, he wished to draw attention to the miserable condition of many towers and spires throughout England. A remarkable instance was the tower of St. Mary's, Taunton. The interior of that edifice was fitted up at a large cost a few years ago by Mr. Ferrey, fellow, but the tower was left untouched, and it was now in a wretched state of dilapidation and decay from top to bottom. St. Stephen's, Bristol, which had a curious arrangement of open work, similar to that at Taunton, was also in a decayed state; but dilapidation itself was even better than some modes of repair. He had been on the day previous at Dundry, a village in Somersetshire, four or five miles from Bristol, and the church tower there had open work at the top, something like that at St. Stephen's, Bristol but yet possessing interesting peculiarities of its own. The upper part of the tower falling into decay, an architect was consulted, who recommended the rebuilding of the decayed portions, at a cost, which he estimated would be about 300*l.* The parish blacksmith, however, who, being one of the vestry, was all powerful, said he could mend it for 40*l.*; and accordingly he had encased it with the most amusing elaboration of iron net-work ever beheld. Cross bars of iron traversed the tower in every direction, and this mode of repair would in a few years hasten the whole pile to destruction. The tower, which was a beautiful specimen of the style common in the sixteenth century, was in a good state, except the top; and he repeated, that the means used for its repair must inevitably in a few years destroy the whole. It was, indeed, most important that parish authorities should listen to that which was repeated almost every day, namely that they ought in such cases always to call in proper professional advice, and not merely call it in, he would add, but take it.

Mr. Tite.—I am glad, and I am sure all here present are delighted, to see our old friend Mr. Britton, again amongst us. Let us hope it is a pleasure which will again gladden us. Our friend states that Mr. Wickes is anxious to publish the series of drawings, in outline here exhibited. Every artist would desire to see them published in outline; to the profession that would certainly be the most useful and acceptable form. As a group of buildings they are honourable to the country and to our native architecture. I do not think that any other country in the world could furnish the originals for such an admirable series of drawings as those now exhibited. There are few countries that could match, or at least excel, any of them in beauty. In all Normandy, I only remember one church which I could describe as worthy to be ranked with these; that was at Lillebonne, a town famous for Roman remains; and I was delighted to find, on inquiring after its architect, that it was attributed to an Englishman, who had settled permanently in that part of the country. I mention the circumtance as a proof that English church architecture has a distinctness of character, which would almost of itself constitute a separate school of the art.

Mr. Fowler alluded to the peculiar characteristics which prevailed in the towers of churches in different parts of England. This point had, no doubt, struck other gentlemen, and he should like to hear a dissertation upon it from some one, if not from Mr. Britton. In Devonshire, Somerset, and Wilts, there were general peculiarities clearly traceable, which had no connection whatever with any feature of the country round about. Mr. Godwin had referred to the church at Taunton. He had long resided in that town, and was well acquainted with that splendid specimen of architectural taste, the tower of St. Mary's, although he confessed it was not until he had diligently compared it with others, that he became convinced that it was the most beautiful tower of that class in all England, and it presented as curious a network of iron bars as he saw at Dundry. He quite agreed with Mr. Godwin, that the introduction of iron into masonry could not fail to be attended with injurious effects. He trusted the attention of the public would be called to the subject, and steps would be taken to restore and preserve St. Mary's, Taunton, to the condition in which its excellence entitled it to be maintained.

Ruins of an Ancient Californian City.—Antiquaries will feel deeply interested in the discovery of vast regions of ancient ruins near San Diego, and within a day's march of the Pacific Ocean, at the head of the Gulf of California. Portions of temples, dwellings, lofty stone pyramids (seven of these within a mile square), and massive granite rings or circular walls, round venerable trees, columns and blocks of hieroglyphics—all speak of some ancient race of men now for ever gone, their history actually unknown to any of the existing families of mankind. In some points, these ruins resemble the recently discovered cities of Palenque, &c., near the Atlantic or Mexican Gulf coast; in others, the ruins of ancient Egypt; in others, again, the monuments of Phœnicia, and yet in many features they differ from all that I have referred to. I observe that the discoverers deem them to be antediluvian, whilst the present Indians have a tradition of a great civilised nation, which their ferocious forefathers utterly destroyed. The region of the ruins is called by the Indians "the Valley of Mystery."—*American Correspondent.*

THE ENTASIS OF A COLUMN.

Description of a method invented by Mr. Jopling for describing the Entasis of a Column, or Spire, and some other Curves adapted to Architectural Lines. By F. C. Penrose, Esq.—(Paper read at the Royal Institute of British Architects, March 18th.)

There are few gentlemen here, who will not allow, that a curve of strictly varying curvature is more beautiful and appropriate than one, like the false ellipse to which I point, which is made of several circles, each mutilated segment of which suggests its own completion, and interferes with the general line composed of the several arcs. And no one will deny, that, if it can be shown that varying curves can be constructed easily, we ought to apply them whenever possible, instead of the broken lines so often used. I was led in following out an examination of the curves used by the Greeks, to endeavour to invent an instrument for drawing by continued motion the hyperbola, a curve frequently used by them in the profiles of their mouldings, and the entasis of their columns; and I succeeded in arriving at an instrument, which, by a very slight modification of the method of drawing the conchoid of Nicomedes, of which I produce some examples, draws the hyperbola with the greatest exactness. I had not gone far in this study, before I found that Mr. Joseph Jopling had made many valuable discoveries in various methods of drawing curves by machinery, the principles of some of which he has recently published in a small pamphlet, named the 'Impulse to Art.' In this he describes a method for drawing the Ionic volute by a particular and simple arrangement of three cranks, or a crank and two strings, like the instrument I lay before you; and by another arrangement of the same instrument, he produces a very beautiful ogee, called by him the line of beauty, of both of which he has lent me specimens of a large size, drawn by him to lay before you this evening. I was enabled by applying his method deduced from the 'Impulse to Art,' without any assistance from him, to arrive at so near an approximation to the volute of the Ionic column of the Propylæa, of which Mr. Willson and I obtained exact measurements at Athens, that I can hardly resist the conclusion that Mr. Jopling has discovered the method used by the Greeks in drawing their volutes. He assures me that he has found equally, if not more, satisfactory comparisons from the volutes of the Erechtheum and other buildings.

What I have chiefly undertaken to bring before you this evening, is a method for drawing the entasis of a column, or a spire. We suppose it to be granted (which perhaps is not absolutely certain) that a spire ought to have an entasis. It probably depends upon the effect we wish to give to the spire, whether it should be straight-sided, or have the usual convex entasis, or concave entasis, as the latter may be called where the sides are hollowed. Mr. Jopling's instrument, which is very simple, is equally adapted to either case. It consists of two principal parts: a flat straightedge, the sides of which, instead of being parallel to one another, diminish at a small angle; the one for instance which I produce, is 3 feet 6 inches long, at one end 3½ inches, and at the other 1½ inch broad. The other part is a bar with one fixed peg at the end, and two moveable sockets, one of which carries a peg, the other a pencil tube. Nothing more or less than the bar of an ordinary trammel and the tapering straightedge: it is the same in principle as the trammel, only much more convenient for the drawing of very flat ellipses than that instrument in its ordinary construction. This might be applied full size to the column or spire, with great ease, though it may be questioned whether that be really so good a way as that of obtaining the curves more at ease, and setting them off from straight directing lines. In drawing the entasis however on paper, to any attainable size, its action is most simple. To produce a very flat ellipse, we have only to set the two pegs at some convenient distance, rather greater than the broader part of the straightedge, and the pencil at some convenient distance along the bar. By sliding the bar along the straightedge, keeping the two pegs in contact, and the pencil on the paper, which is, after a little handling, very easy to do, with proper elbow room and other convenience of standing room, we produce a portion, nearly the half, of an exceedingly flat ellipse; the part nearest the vertex having very sharp curvature, and the parts removed from it being almost straight: so that by a proper selection of a portion of this arc, we may obtain a curve of whatever variety we please, constantly varying also its curvature according to a regular law, altogether superior to anything that can be put together by parts of circles and straight lines, for those purposes at least to which it can be applied.

There are numerous other forms of curves, that could be advantageously applied to architectural purposes, several of which Mr. Jopling has produced. One, which I here point out, is described by an instrument devised by myself, and which draws very complicated forms, available for some purposes in their entire state, and for others by a proper selection of parts, so as to be made applicable for the curves of vases and other lines, and these always suggest beautiful motives for lines of varied curvature. On the present occasion, however, time does not allow me to enlarge upon them, and I must conclude by again calling to your notice the extreme simplicity of the instrument, which Mr. Jopling's kindness has allowed me to lay before you, and which is most readily adaptable for drawing what is often required in Architecture, a long line departing very little from a straight line, and yet with an almost unlimited variety in its curvature.

MOTION OF WATER IN PIPES.

On the Motion of Water in Conduit Pipes; on Friction and Pressure in Pipes; and on Jets d'Eau. By M. D'Aubuisson de Voisins, Ingenieur en chef Directeur au Corps Royal des Mines, &c. &c. —(Translated by T. Howard, for the *Civil Engineer and Architect's Journal.*)

(*Continued from page* 132.)

Equation where Conduits are terminated by Adjutages.

12. We have hitherto considered conduits as entirely open at their further extremity; whereas, they are generally terminated by nozzles or cocks, or have some kind of adjutage which contracts the opening, and makes the water issue forth with a velocity different from the uniform motion of the fluid in the pipe: consequently, the equations (I. to XII.) based upon the supposition of identity of velocity, do not apply except under that condition. The first member of these equations, $H - {\cdot}155v^2$, gives the portion of the head destroyed by the resistance of the conduit; which portion is the entire head H, minus that which remains to produce the velocity of discharge (2): if this velocity is called V, the first member of the equation will, in general, be $H - {\cdot}155\,V^2$. The second member is the expression of the resistance of the sides (7), which is a function of the velocity in the conduit, or of v; v ought then to remain as it is in this member, which will not change in value.

13. In conduit pipes, even more, if possible, than in other cases of fluids with unbroken continuity of motion, the velocities, at particular points, are in inverse ratio to their sections: so that if d be the diameter of an adjutage at its discharging orifice, m the coefficient for its particular contraction, D being invariably the diameter of the conduit, we have

$$V : v :: \pi' D^2 : \pi' m d^2; \quad \text{or,}$$

$$V = v \frac{D^2}{md^2} = 1{\cdot}273 \frac{Q}{D^2} \times \frac{D^2}{md^2} = 1{\cdot}273 \frac{Q}{md^2}.$$

The equation for the movement then becomes

$$\left.\begin{array}{ll} \text{[In mètr.]} & H - {\cdot}08264 \dfrac{Q^2}{m^2d^4} = {\cdot}002221 \dfrac{L}{D^5} (Q^2 + {\cdot}0432\,QD^2) \\ \text{[In feet.]} & H - {\cdot}02519 \dfrac{Q^2}{m^2d^4} = {\cdot}000677 \dfrac{L}{D^5} (Q^2 + {\cdot}14173\,QD^2) \end{array}\right\} \ldots\text{(XVI.)}$$

Of the five quantities which this equation contains, four being given, we may by it obtain the value of the fifth.

It is required, for example, to determine the diameter necessary to give to a circular orifice in a thin plate, fitted to the end of a conduit of ·08 feet diameter, and 532 feet long, the quantity of water to be discharged per second being ·02 feet, and the head 4·5 feet. The above equation will give

$$d = \sqrt[4]{\frac{{\cdot}02519\,Q^2D^5}{m^2\left\{HD^5 - {\cdot}000677L(Q^2 + {\cdot}1417QD^2)\right\}}}.$$

Puttting in the numerical valnes $m = {\cdot}62$, and reducing and extracting the fourth root, we have $d = {\cdot}0477$ feet.

14. For velocities above 2 feet per second, we have (all being in feet),

$$H - {\cdot}02519 \frac{Q^2}{m^2d^4} = {\cdot}000711 \frac{LQ^2}{D^5}; \qquad \text{(XVII.)}$$

$$Q = 37{\cdot}034 \sqrt{\frac{HD^5}{L + 35{\cdot}47\dfrac{D^5}{m^2d^4}}}; \text{ and} \qquad \text{(XVIII.)}$$

$$D = {\cdot}235 \sqrt[5]{\frac{LQ^2}{H - {\cdot}02519\dfrac{Q^2}{m^2d^4}}}. \qquad \text{(XIX.)}$$

Ex. 1.—To a conduit of the dimensions given below, we will adapt a conical adjutage ·03 feet diameter: we require to know the quantity it will then discharge?

Here $D = {\cdot}25$ feet; $L = 1450$ feet; $H = 5{\cdot}32$ feet; and for the coefficient for the convergence of the adjutage we take ·90. Consequently,

$$m^2d^4 = {\cdot}0000006561; \quad \text{and } 35{\cdot}47\frac{D^5}{m^2d^4} = 52795.$$

$$\text{Then } Q = 37{\cdot}034\sqrt{\frac{5{\cdot}32\,({\cdot}25)^5}{1450 + 52795}} = {\cdot}01146 \text{ cub. feet.}$$

The complete equation (XVI.) would also give ·01146 cub. feet.

We would here remark, that if instead of an adjutage of ·03 feet diameter, we put one of ·125 feet diameter (half the diameter of the conduit), the discharge will be .. .. ·06551 cub. feet.

With a diameter of ·1875 feet (¾ diameter) . .. ·06881 cub. feet.

Without any adjutage, we should have .. .. ·06917 cub. feet.

These results show, that when the diameter of an adjutage is great compared with that of the conduit (so as to be more than half thereof), the discharge differs very little from that which we obtain by leaving the conduit entirely open.

In several of my experiments on the conduits of Toulouse, this fact was particularly observed; the difference in some cases was even much less than theory would give—it was imperceptible. For example, having at the end of a conduit of ·164 feet diameter, and 1391 feet long, successively fitted plates pierced with circular orifices, gradually decreasing in diameter, and under a constant head of 53·5 feet, we had the discharges here given. The diameter of the conduit being ·164 feet, the first is the result obtained without any adjutage. We observe that the results of calculation approach so much the nearer those of experiment, as the velocity of the water in the conduit becomes less.

Diameter of Orifice.	Discharge according to	
	Calculation.	Experiment.
Feet.	Cubic Feet.	Cubic Feet.
·164	·07558	·06074
·115	·07417	·06074
·098	·07311	·06074
·066	·06463	·05080
·049	·05192	·04697
·033	·02967	·02896

Ex. 2.—Required the diameter of a conduit 2736 feet long, and from which, with a head of 21·3 feet, we wish to obtain ·4 cub. feet of water per second, by several orifices placed near each other, and which taken together are equal in area to one circular orifice ·13 feet diameter; the coefficient of contraction in this case being taken as ·85?

$$\text{We have } m^2d^4 = {\cdot}000206346; \quad {\cdot}02519\frac{Q^2}{m^2d^4} = 19{\cdot}547; \text{ and, consequently}$$

$$D = {\cdot}235\sqrt[5]{\frac{2736\,({\cdot}4)^2}{21{\cdot}3 - 19{\cdot}547}} = {\cdot}641 \text{ feet.}$$

ART. II.—CONDUITS WITH BENDS AND CONTRACTIONS.

Three kinds of Resistance in Conduit Pipes.

15. We have been hitherto considering conduits as rectilinear, and of equal section throughout their whole length; but they are generally formed with angles or bends, and occasionally have parts of a diminished section, either over a very small extent (forming, as it were, an annular contraction), or else through a considerable length. Water, moving in such conduits, on arriving at the bends, is compelled to change its direction. In so doing, it loses part of its velocity: the resistance which causes the loss is as a force opposed to the motive power, or the original head; it destroys a part thereof.

At contractions, again, the fluid experiences another resistance: having there to pass through a narrower section, it requires to have a greater velocity; to obtain this, a new effort is necessary—and the consequence is, another diminution of the total head.

Thus, water, in its motion in pipes, meets, or may meet, with three kinds of resistance—that due to the effect of the sides, and which is by far the most considerable; that which arises from bends; and that from contractions. The forces or portions of the head employed to overcome these, lessen the total head; and it is only by reason of the remaining part, that the efflux takes place: this portion is the height due to the velocity of discharge.

We have treated in detail the resistance of the sides (4—8); we shall now examine the other two.

The Resistance of Bends and Angles.

16. Every moving body, which after having followed a certain direction suddenly changes therefrom, loses a portion of its velocity, represented by the versed sine of the angle formed by the two directions. If it moves in a curved line, it is continually changing its direction; but the loss of velocity at each change is only an infinitely small one of the second order; and consequently, although the number of losses be infinite, the total loss will be only an infinitely small one of the first order, or as nothing: in other words, every moving body which arrives tangentially at a curve, and follows it for some length, possesses on quitting it the same velocity it had on its arrival. It follows, that if a bend in a conduit be well formed, and the fluid therein should exactly follow the curve, it would suffer no resistance or loss of velocity.

But this is not the case: the molecules composing the fluid current being independent of each other, while those which are in contact with the sides would follow the curvature, the others, being directed against the sides, will be reflected by them, or by the intervening particles, at an angle which is sometimes very considerable. For example, the central fillet *a*C has a tendency to strike the side ACB at C, and from thence to be reflected in the direction C*b*. The mutual action of the particles on one another, will produce, in the whole, a loss of velocity; it will be, generally, less than that of the central stream taken alone, but always greater than that of the current bordering on the sides.

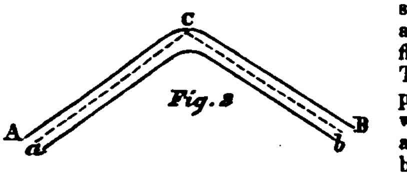
Fig. 2

This diminution of velocity, and consequently of discharge, although certain, will yet be very slight. Thus, Bossut, with a pipe of 1·06 inch diameter, and 53¼ feet long, laid horizontally in a straight line, and with a head of 1·07 feet, obtained a discharge of ·7360 cubic feet per minute: then having bent it in a serpentine form, so as to have six well rounded curves, all else remaining the same, he obtained ·7205 cubic feet per minute.

We may, however, by multiplying and increasing the acuteness of the bends, render the diminution of discharge very considerable. Rennie, with a lead pipe, 15 feet long, and ½-inch diameter, fitted horizontally to a reservoir under a head of 4 feet, obtained a discharge of ·419 cubic feet per minute; then having given the same pipe fifteen semicircular bends, of 3¼ in. radius, and again fitted it to the reservoir, the discharge was not more than ·370 cubic feet: so that the fifteen bends reduced the discharge in the ratio of 100 to 89; with a quadruple head, the reduction was in the ratio of 100 to 88.

17. With regard to the laws regulating the resistance of bends, and to its amount, we are indebted to Dubuat for the first well-observed facts. He has taken various pipes, at first rectilinear, and measured the head necessary to obtain from them a certain volume of water in a certain time: he has then bent them in different forms, and in such a manner that the central current had a tendency to be reflected at angles of determined number and acuteness, and again examined the head with which they discharged an equal volume of water in an equal time. The difference between the two heads, for the same pipe, at one time rectilinear and at another bent, was evidently the head due to the bends, and consequently the measure of their resistance. The principal of twenty-five experiments, which he has thus made, are given in the following table:—

PIPE.			Velocity per Second.	Resistance due to the Bends.	Coefficient Deduced.
Diameter.	Length.	Angles. Number & Value.			
Inches.	Feet.		Feet.	Feet.	
1·07	10·39	1 of 36°	7·55	·067	·0034
1·07	10·39	2 of 36	7·55	·133	·0034
1·07	10·39	3 of 36	7·55	·221	·0037
1·07	10·39	4 of 24·57	7·55	·133	·0034
1·07	10·39	10 of 36	6·36	·524	·0037
1·07	12·40	4 of 36	5·16	·146	·0039
1·07	12·40	4 of 36	2·60	·036	·0039
1·07	65·46	4 of 36	2·54	·035	·0039
2·13	22·66	4 of 36	7·66	·257	·0030
2·13	22·66	4 of 36	5·22	·118	·0031
2·13	22·66	6 of 24·57 5 of 36 1 of 56·23	7·66	·767	·0038

Dubuat concludes from his experiments, that the resistance arising from bends is proportional to the square of the velocity of the fluid, to the number of angles of reflection, and to the square of their sines.

In this hypothesis the coefficient varies but little, and its mean value is ·0037. So that if v be the velocity; n, n', &c. the number of angles of reflection of equal measure; i, i', &c. the respective measures of the angles, the resistance will be

$$\cdot0037\,v^2\,(n \sin^2 i + n' \sin^2 i' + \ldots\ldots\ldots\ldots\ldots);$$

or in function of Q, and taking s for the sum of the squares of all the sines, $\cdot0061\,\frac{Q^2}{D^4} \times s^2$.

18. In the application of this formula to any given conduit, we must determine the number and value of the angles of reflection for each bend. Now, a simple diagram shows, 1st, that in a pipe bent to an arc of a circle (and no other curves need be admitted in practice), half the diameter of the pipe divided by the radius of the arc, will give the versed sine of the angle of reflection, and we may consequently get its cosine and value in degrees; 2ndly, that the number of degrees in the arc (*i. e.* the supplement of the angle of the curve), divided by twice the angle of reflection, will indicate the number of angles.

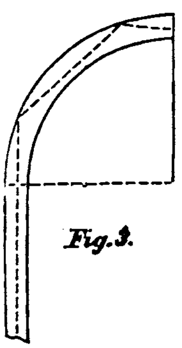
Fig. 3.

Let us, for example, take a conduit pipe, ·82 feet diameter, conveying 1·76 cubic feet of water per second, and which presents a bend of 95°, the radius of the curve being 6·89 feet: what will be the resistance occasioned by this bend?

According to the rule laid down, the versed sine of the angle of reflection will be ·0595 $\left(=\frac{\cdot41}{6\cdot89}\right)$, and its cosine ·9405 $(=1-\cdot0595)$, tha cosine of an angle of 19° 52′; this is the angle of reflection. The arc of curvature 85° $(=180°-95°)$ divided by 39·73° (twice the angle of reflection), will give their number; this we shall take as 3, the quotient being 2·14. The sine of 19° 52′ is ·3398, and its square ·1155: the resistance sought will therefore be

$$\cdot00608\,\frac{(1\cdot76)^2}{(\cdot82)^4} \times 3 \times \cdot1155 = \cdot0144 \text{ feet};$$

a quantity extremely small, although the curve was tolerably acute and the velocity considerable. For the pipe with fifteen bends, in Rennie's experiment, the above method of calculation would give a resistance of ·633 feet: the experiment itself, as we shall shortly see, gave 1·16 feet, which would raise the coefficient of Dubuat from ·00608 to ·01113. But such a case as this seldom occurs in practice; nor does the value of the resistance, even if we double the coefficient, often amount to an inch loss of head.

We may neglect account of the value of this resistance in curves of great radius; the angles of reflection, it is true, will be greater, but not so strong; and the sum of the squares of the sines, and consequently the resistance, will be less.

19. If the effect of well curved bends is imperceptible, it is not so with angles, properly so called. An experiment of Venturi shows their influence: this *savan* had three tubes made, 1·25 feet in length, and 1·3 inch diameter; one was rectilinear, the second had a bend of 90° well curved, and the third had an acute angle, also of 90°: under a head of 2·88 feet, they filled a vessel containing 4·84 cubic feet, respectively in 45″, 50″, and 70″. The bad effect of angles is shown still more plainly in the experiments of Rennie: with his pipe 15 feet long, ½-inch diameter, and with a head of 4 feet, he obtained, per minute, a discharge

With the rectilinear pipe	·419	cubic feet.
With the fifteen semicircular bends ..	·370	"
With 1 right angle	·333	"
With 24 right angles	·152	"

so that one angle of 90° reduced the discharge more than 15 considerable bends. This fact alone shows with what care all angles should be avoided in the establishment of conduit pipes.

In seeking the heads which made the three pipes with bends or angles give a discharge (·419 cubic feet) equal to that which was obtained when there was neither angle nor bend, we find them respectively 5·15, 6·33, and 30·52 feet. Deducting 4 feet, there remains for the resistance arising from the bends and angles (17) 1.15, 2·33, and 26·54 feet. From which we conclude that the resistance from a single angle of 90°, was more than double that of fifteen bends; and that of twenty-four angles was only 11·4 times greater than that of a single one. This last result also shows that the resistance of angles and bends is not proportional to their number, as Dubuat had remarked. I had also observed a like want of proportion in my *Experiments on the motion of Air in Conduit Pipes* ('Annales des Mines,' 1828, p. 453).

Resistance arising from Contractions.

20. Contractions, of which we are about to treat, are occasioned by a diminution of the section of the conduit for a very short length.

That we may give an exact idea of the resistance they offer to the motion, let us suppose a conduit in which, perpendicular to its axis, we have placed a diaphragm or thin partition pierced with an orifice. The stream, on arriving at this point, will contract and reduce itself to the size of the aperture, taking a greater velocity in proportion as the section is smaller; and this velocity will always be greater than it would have been in this part of the conduit without the partition. The force necessary to produce the extra velocity, the direction of the motion remaining the same, will evidently be due to the resistance offered by the contraction.

Let B be the diameter of the orifice, *m* its coefficient for contraction. The velocity through this point requiring to be greater than in the conduit, and following the inverse ratio of the sections, will be then expressed by $\cdot 0155 v^2 \frac{D^4}{m^2 B^4}$. The excesses of force, or loss of head arising from the contraction, will therefore be

$$\cdot 0155 v^2 \left(\frac{D^4}{m^2 B^4} - 1\right) = \cdot 0155 v^2 D^4 \left(\frac{1}{m^2 B^4} - \frac{1}{D^4}\right).$$

In terms of the discharge, this resistance will be expressed by

$$\cdot 02519\, Q^2 \left(\frac{1}{m^2 B^4} - \frac{1}{D^4}\right).$$

M. Navier, considering that the stream, on passing out of the contraction, immediately resumes the velocity proper to the conduit, instead of the difference between the squares of the two terms, $\frac{1}{mB^2}$ and $\frac{1}{D^2}$, takes the square of their difference, $\left(\frac{1}{mB^2} - \frac{1}{D^2}\right)^2$. But as this opinion is contrary to fact, as the experiments given in the next section will show, we must be careful in adopting a result founded on false premises.

It is but seldom, however, that we shall have to make use of the above formula, for in a conduit pipe there ought not be any sensible contraction: should one accidentally be found, this formula will serve to give us the value of its resistance. It will generally be slight; in some experiments made with sluice valves fixed in the conduits of Toulouse, I found, after diminishing the section of one of them by $\frac{24}{100}$, that the discharge was only reduced $\frac{1}{100}$.

21. If, in the same conduit, below the first contraction there be a second, a third, &c., the resistance from each may be determined by the above formula, and their sum taken.

But, in order that these resistances may be thus added, they must be independent of each other; that is to say, the fluid, after passing through the first contraction, must have recovered the general velocity of the conduit before reaching the second. If it were not so, the fluid stream, after leaving the first contraction, would preserve entirely, or in part, the excess of velocity which it had acquired in order to pass through; and a less effort would be necessary for the second, and less in proportion as the distance between the contractions was smaller.

Eytelwein has made many experiments which fully demonstrate this fact. He took tubes 1·03 inch in diameter, at either end of which was a copper plate pierced with an orifice ·51 inch diameter; their length, or distance between the orifices, being given in the first column of the accompanying table. They were fitted horizontally to a reservoir, and the discharge made by each ascertained; this discharge, as compared with the theoretic discharge, which is represented by unity, is contained in the second column: it goes on gradually diminishing, and consequently indicating the resistance increasing, in proportion as the distance between the two orifices is greater. Eytelwein again fixed in a tube 1·03 inch diameter, four thin plates, each pierced with an orifice of ·256 inch diameter, and at a distance of ·256 inch from each other; the discharge was then ·622. When, however, the plates were placed at the distance of 1·03 feet from each other, the discharge was not more than ·0331.

Distance.	Discharge.
Feet.	
·023	·626
·043	·622
·085	·614
·171	·568
·260	·509
·430	·487
1·030	·481
2·060	·478

22. The observations we have made respecting contractions caused by thin plates pierced with orifices, apply equally to those which would be produced by very short tubes of a diameter smaller than that of the conduit. I cite the 24th Experiment of Venturi. This eminent philosopher, with great judgment, arranged his apparatus to consist of two sorts of tubes alternately; the one B, B, were ·148 feet long, and ½-inch diameter; the other C, C, were 1·9 inches diameter, and their length sometimes ·289 feet, and sometimes ·564 feet. He at first made use of a single tube C; then of two, of three, of four, and lastly of five: he successively applied these various combinations to a reservoir, using a constant head of 2·89 feet, and the following are some of the discharges obtained:—

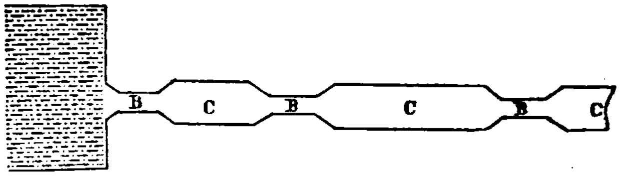

Fig. 4.

With a single tube, B	·0444 cub. feet.
With a tube, C, added	·0329 „
With three tubes, C	·0252 „
With five tubes, C	·0202 „

I have attempted to compare these results with those by the methods of calculation I have given: the differences have been sometimes great, sometimes inconsiderable; thus, for the last case I have had ·0185 cubic feet.

23. Notwithstanding the great irregularities which these results present, they are well worthy attention, and principally on account of the very striking manner in which they show the effect produced by enlargements in a pipe; an effect, carried above a certain limit, altogether as prejudicial as that of contractions.

Venturi's entire apparatus, which was 3·2 feet long, may be considered as a pipe ½-inch diameter, having the five enlargements C. It furnished, as we have seen, a discharge of ·0202 cub. feet. He afterwards, with a tube of the same length, but of the uniform diameter of ½-inch, obtained ·0327 cub. feet. The enlargements thus diminishing the discharge in the ratio of 100 to 62.

24. There is yet one other contraction that ought to be considered—that experienced by the fluid stream on its entry into a pipe of less diameter than that which immediately precedes it. The resistance arising from this contraction will evidently be the same as if, at the entry of the pipe, we had placed a plate pierced with an orifice of which the section should be to that of the pipe as *m* to 1 (*m* being the coefficient belonging to the contraction); and its expression will then be

$$\cdot 02519 \frac{Q^2}{D^4}\left(\frac{1}{m^2} - 1\right);$$

This is a special case of the general formula (20), where $B = D$.

The value of *m* can only be approximatively. For a very short pipe, as for cylindrical adjutages, it will be ·82. But in pipes, properly so called, it approaches nearer to 1; and more so in proportion to the length of the pipe, and even, according to M. Prony, as the diameter is greater; so that in large conduits, the effect of this contraction is very small. It is still further reduced by connecting pipes of two diameters by a conical length, gradually diminishing from one to the other.

Lastly, as we have remarked (5), the effect of the contraction at the head of a pipe is implicitly comprised in the values of the coefficients of the fundamental equation; and its effect at the entry of a pipe which branches from a larger conduit, will be comprised in the determination of the head of such branch, so that we need not in any case make calculation of it.

Observations on the Practical application of the Formulæ.

25. The coefficients of the formulæ which we have given, especially those concerning the principal resistance—that due to the friction against the interior of the pipe—have been determined by experiments made chiefly on pipes of small diameter and of no great length (5); they have been generally well-bored pipes, well joined, and free from incrustations. But can such formulæ be safely applied, without modification, to conduits of a different description—namely, to those used in large distributions of water? This is a question which we must now examine.

The pipes of which conduits are formed are almost always more or less imperfect, from the effect of the mould, or in casting; their section is no longer exactly circular, and consequently, *cæteris paribus*, it is smaller than it ought to be. Their interior surface presents inequalities which retard the motion. When joined, the axis of the whole is not always a line without rebatement; the interior is not a perfectly cylindrical surface; the edges of some of the pipes project, and the currents reaching these points, are arrested, divided, and sometimes reflected back again: thus arise eddies in the movement, loss of motive force, and consequently a diminution of the discharge. Even when the pipes are well cast, so that the channel is very regular, there will be nevertheless, at each joint, a little annular hollow, or a break of continuity, which will produce, to a certain extent, the effect of projections; and which, repeated at every joint in a long conduit, cannot but give rise to a perceptible reduction in the discharge. M. Gueymard, *ingenieur des mines*, has rightly insisted on this cause of reduction, and has endeavoured successfully to obviate its effects in the establishment of the fountains at Grenoble.

Moreover, when the conduits are sinuous in their vertical planes (as is generally the case), if there are no vents at the summits of the highest parts, the air which the water carries with it, and which is disengaged in a greater or less quantity, rises into these elevated parts, and being there collected, produces the effect of contractions, the bad effects of which we have already seen. The cleanest waters, in appearance, always carry with them foreign bodies, and especially extremely fine earthy particles, which are deposited in parts of the pipe; and in time contracting the section, again diminish the discharge. I do not here speak of calcareous and siliceous matter, which, although held in solution in the water, become precipitated on the interior of the pipes, lining them with a stony crust, and, gradually increasing in thickness, would end by stopping them altogether, if not removed in time: this evil is peculiar only to certain localities. It is the same with regard to ferruginous deposits, which are made in a tubercular form in the conduits of Grenoble, and which continually increasing in number and size, diminish the discharge to such a degree that, in eight years, it has been reduced more than one-half. The aërated water, running in pipes, likewise attacks the material, and forms a hydrate of iron, which is deposited in long nipples parallel to the direction of the current, and in greatest quantity on the lower part; underneath these, the iron is as it were corroded, nearly to $\frac{1}{10}$th of an inch. ('Annales des Mines,' 1834, p. 203, *et. seq.*)

Setting aside these local circumstances, it often happens that in experiments made on conduits apparently in a sound state, the discharge has been found to be less by a quarter or a third than that indicated by the formulæ: it is scarcely ever equal to it. I have quoted many of these experiments in my 'History of the Formation of the Fountains at Toulouse.' In consequence of these ascertained facts, the hydraulic engineers of Paris, when making use of the formulæ of discharge, diminish by one-third the value of the numeric coefficients. I have adopted an analogous method, by augmenting by one-half the quantity of water which should determine the size of the conduit. It is, in my opinion, with such latitude that an engineer charged with the establishment of a plan for a large distribution of water, ought to employ the formulæ which we have set forth: he will then avoid the disappointments which would often occur if he uniformly adhered to results given by conduits made with a precision which can seldom belong to his own.

(To be continued.)

ON THE ART OF NAVIGATION.

An Exposition of the Art of Navigation, as applicable to Inland Transit, and of the Works by means of which our Communication with the Ocean is improved and maintained. By David Stevenson, Esq., F.R.S.E.—(Paper read before the Royal Scottish Society of Arts.)

Mr. Stevenson believed he was perfectly safe in affirming, that nothing had occupied a more prominent part in the work of civilising the world than the art of navigation, which had slowly but steadily progressed since the commencement of the 14th century, at which early period the introduction of the mariner's compass opened up a new era in the history of maritime discovery, and gave an entirely new character to commercial enterprise. In its more extended sense, the subject of navigation had, for the last 400 years, formed the grand object on which the labours of Columbus, and of all subsequent explorers of the world, had been expended, while the researches of the philosopher, ths astronomer, the geographer, the mechanician, and the engineer, had all been instrumental in bringing to their present maturity and perfection the various branches of which the vast system of navigation, as it now existed, was made up.

It is not, however, to the subject in that comprehensive sense that he had the honour, at the request of the Council, to direct the attention of the Society. Such an exposition would embrace too wide a field, aud lead to the discussion of topics which would not fall within the scope of civil engineering; and he would therefore confine his observations to that branch of navigation which he defined as the department which intervened between the ocean and the land—a connecting link, the true importance of which could be correctly estimated only when viewed in connection with the vast importance of the whole system of which it formed an indispensable part. For how, he asked, could we be benefited by those mighty results of science and of art by which sailing vessels of all classes were now enabled to transport their cargoes from shore to shore with comparative ease and safety, and gigantic steamers to cross the Atlantic with certainty and despatch, did we not extend the beacon light to welcome their approach to our coasts, and provide the means of their withdrawing from the ocean billows into sheltered havens, where their lading might be discharged, and cargoes of our country's produce shipped for foreign lands?—for it must be remembered that it was only when a mariner approached his destined port that the many dangers caused by rocks, shoals, sand-banks, tides, and currents, beset his course; and hence the necessity of employing artificial means to secure that shelter and protection which his vessel required. It would at once occur to the Society that works of various kinds were employed for this purpose: one class of these works consisted in the projection of piers and breakwaters at suitable situations on the coast, so as to form sheltered havens and harbours of refuge; to another department belonged ship canals, by means of which exposed coasting voyages were avoided, and vessels were brought by sheltered and direct routes to their destination; while closely connected with this might be mentioned the system of inland navigation, as effected by the means of canals and the upper compartments of rivers; and last of all, there was that varied class of works by which inlets of the sea, and tidal compartments of rivers, extending from the coast into the country, were opened up and rendered navigable; and he observed in passing, that these various works, connected with the improvement of navigation, formed by far the most extensive and intricate department of hydraulic engineering.

On the subject of harbours formed by the projection of piers and breakwaters, he did not intend to enter at present, and only requested the attention of the Society while he endeavoured to convey an outline of what he conceived to be the extent of our knowledge with reference to the subjects of inland and tidal navigation.

Mr. Stevenson said, that the antiquity of navigable canals—their wide-spread introduction for the transport of goods, and the important place which they had so long occupied in the commercial history of every country—rendered their origin and subsequent progress worthy of attentive investigation; but that only a very brief notice of that class of works could be given. And on that subject he remarked, that from the writings of Herodotus, Aristotle, Pliny, and other ancient historians, we learned that canals existed in Egypt before the Christian era; and at the same early period there was reason to believe that artificial inland navigation also existed in China. Almost nothing, however, save their existence, had been recorded with reference to these very early works; but soon after the commencement of the Christian era, canals were introduced, and gradually extended, throughout Europe, particularly in ancient Greece, Rome, modern Italy, Spain, Russia, Sweden, Holland, and France.[1]

In speaking, however, of the earliest of these works, Mr. Stevenson said that it was not to be supposed that they resembled the present system of inland navigation as practised and known in this country. Early as canal navigation was introduced, it was not until the invention of canal-locks, by which boats could be transferred from one level to another, that the system was rendered generally applicable and useful; and a writer in the *Quarterly Review* remarked, "that to us living in an age of steam-engines and daguerreotypes, it might appear strange that an invention so simple in itself as the canal-lock, and founded on properties of fluids little recondite, should have escaped the acuteness of Egypt, Greece, and Rome."[2] But not only had the invention escaped the notice of the ancients, but the several gradations made towards the attainment of that simple but valuable improvement, appeared to have been so gradual, that, like many discoveries of importance, great doubts existed, not only as to the *person*, but even as to the *nation* by whom canal-locks were first introduced. One class of writers attributed the discovery to the Dutch, and Messrs. Telford and Nimmo, from whose pen the article on Inland Navigation in Brewster's 'Edinburgh Encyclopædia,' was understood to have emanated, adopted the conclusion that locks were used in Holland nearly a century before their application in Italy; while, on the other hand, the invention had been strongly, and not unreasonably claimed by engineers of the modern Italian school, and in particular for Leonardo da Vinci, the celebrated engineer and painter. Without, however, entering into a discussion on this subject, he would simply remark, that during the 14th century the introduction of locks, whether of Dutch or Italian origin, gave a new character to inland navigation, and laid the basis of its rapid and successful extension. And here he said that it might be proper to remark,

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[1] Fulton on Canal Navigation. London, 1796.—Vallancey's Treatise on Inland Navigation. Dublin, 1763.—Tatham's Political Economy of Inland Navigation. London, 1799.—Inland Navigation, Brewster's Edinburgh Encyclopædia.

[2] Quarterly Review, No. 146, p. 281.

that the early canals of China and Egypt, although not possessed of locks, were not on that account unadapted to difference of level. It was very doubtful, indeed, if the use of locks had even yet been introduced into China, though intersected by many canals of great extent, the Imperial Canal being nearly 1000 miles in length; and it accordingly appeared that in order to pass boats from one level to another, a rude system of stop-gates and inclined planes had been in use from very early times in that country. Nevertheless the introduction of locks might be held as an important step in the history of inland navigation, and they might be said in Europe and in America to be almost universally used. It was true that inclined planes had been adopted even in this country—in particular on the Shrewsbury and Shropshire canals—and Messrs. Leslie and Bateman had lately recommended this system to the directors of the Forth and Clyde Canal—but the instances of its application were confessedly rare; and, indeed, the only place where he had seen inclined planes extensively used, was at the Morris Canal, in the United States, constructed by Mr. Douglas, of New York, where several planes were in use, having gradients of about one in ten, by which boats weighing, when loaded, about thirty tons, after being *grounded* on a carriage, were raised by water power through a space of fifty perpendicular feet with great success.

But in proceeding to illustrate the progress of inland navigation, he might without tracing its gradual introduction from country to country, remark at once that we found the French at the end of the 17th century, in the reign of Louis the XIV., forming the Languedoc Canal between the Bay of Biscay and the Mediterranean —a gigantic work which was finished in 1681. It was 148 miles in length, and the summit level was 600 feet above the sea, while the works on its line embraced upwards of 100 locks and about 50 aqueducts, the whole forming an undertaking which was a lasting monument to the skill and enterprise of its projectors; and with this work as a model, it did seem strange that Britain should not till nearly a century after its execution, have been engaged in vigorously following this notable example: and this seemed the more extraordinary, as the Romans in early times had executed works in this country which, whatever might have been their original use, whether for the purposes of navigation or drainage, were ultimately, and that even at an early period converted into navigable canals. Of these works he particularly specified the Caer Dike and Foss Dike cuts in Lincolnshire, which were by general consent admitted to have been of Roman origin. The former extended from Peterborough to the river Witham, near the city of Lincoln, a distance of about forty miles: and the latter extended from Lincoln to the river Trent, near Torksey, a distance of eleven miles. The Caer Dike existed now only in name, but the Foss Dike was at this moment an efficient and flourishing navigation: and having been lately professionally engaged in its improvement, Mr. Stevenson stated that he had occasion to inquire somewhat minutely into its past history and condition, and that a very few particulars regarding that, the *oldest* British canal might not be uninteresting.

Among other notices of this early work, Camden, in his *Britannia*, stated that the Foss Dike was a cut originally made by the Romans, and that it was deepened by Henry I., who reigned in the eleventh century, but to what extent it was so deepened did not appear. In 1762 it was reported on by Smeaton and Grundy, who found the navigable depth at that time to be 2 ft. 8 in., and recommended several works for its improvement, which appeared, however, not to have been executed. In 1782, Smeaton was again employed, and deepened the navigation to 3 ft. 6 in.; but it did not appear that its width was increased;[3] and from that period it remained in a very imperfect state till 1840, when the lessee of the navigation employed the firm of which he was a member to design works for assimilating the Foss Dike, both as regarded the breadth and depth of the navigable channel to the rivers Witham and Trent, with which it communicated. When called on to examine the navigation, Mr. Stevenson found its depth to be 3 ft. 10 in., and its breadth in many places was insufficient for the passage of boats, for the convenience of which occasional passing places had been provided; and it was resolved to increase its dimensions and otherwise repair the whole work. Accordingly, the canal was widened to the minimum breadth of 45 feet, and deepened to the extent of 6 feet throughout (alterations which were accomplished without stopping the traffic); the entrance lock was removed, and a pumping engine was erected for supplying water from the river Trent during dry seasons; and that ancient canal, which was quoted by Telford and Nimmo, "as the oldest artificial canal in Britain," was now in a state of perfect efficiency, forming an important connecting link between the Trent and Witham navigations.

Notwithstanding the existence of this early work, however, and of some others in the country, particularly the Sankey Brook navigation, opened in 1760, Mr. Stevenson said that it was generally admitted that the formation of the Bridgewater Canal in Lancashire, the act for which was obtained in 1755, was the commencement of the system of British canal navigation, and that Francis, Duke of Bridgewater, and Brindley, the engineer, who were its projectors, were the first to give a practical impulse to a class of works which now pervaded every corner of the empire, and had been of vast importance in promoting its commercial prosperity.[4]

That the railway system, from the introduction of which we have of late years derived such inestimable advantages, had now, in a very great measure, superseded, and certainly, for the future, must prevent the extension of canals as the means of internal communication, Mr. Stevenson said, was undeniable; and hence at first sight it might appear to some that he was consuming the time of the Society with the details of a subject which, in the present day, might be pronounced to be obsolete. But he reminded the Society, that although this remark might perhaps be considered applicable to such canal works as were intended for the purpose of effecting purely inland communication from town to town, it did not in any degree apply to that more extended class of works called ship canals, which, like the improvement of tidal navigations, were executed for the purpose of enabling sea-borne vessels, by taking an inland course, to avoid the dangers of lengthened coasting voyages—an object of the highest importance to navigation, and which, it was obvious, could not be superseded by the railway system. He presumed, therefore, that he need offer no apology for describing very briefly the characteristics of such canals by reference to works actually executed; and for this purpose he referred to the *Great North Holland Canal*, the largest of the kind in the world. That canal, which extended from Amsterdam to the Helder, a distance of 45 miles, was finished in 1825. It had a cross sectional area, measuring 125 feet in breadth at the surface, 36 feet at the bottom, and no less than 22 feet in depth of water; and what was most worthy of notice, and was, indeed, a characteristic of all the Dutch engineering works, the whole was protected from the German Ocean by embankments, faced with wicker work, the surface of the water in the canal being below the level of the sea. At the time he inspected it the sea was 5 feet higher than the surface of the water in the canal, and the vessels were actually *locking down* from the ocean into the fertile plains of Holland. Its construction was intended to enable vessels trading with Amsterdam to avoid the islands and sandbanks of the dangerous Zuider Zee, the passage through which, in former times, often occupied as many weeks as the transit through the canal now occupied hours. But our own country furnished us with a similar work of great magnitude and boldness; he alluded to the *Caledonian Canal*, which formed an inland navigation composed partly of natural lakes and partly of artificial canal, extending from Inverness to Fort William, a distance of 60 miles, and afforded a depth of 18 feet of water. By means of this inland communication vessels were enabled to avoid the dangers of the Pentland Firth, and also the intricate navigation of the Western Islands: and while the Dutch, in their great canal, had to encounter the difficulties occasioned by the proverbial *lowness* of their country, Telford, in constructing the Caledonian Canal, had to deal with the ruggedness of a succession of Highland glens, and to overcome the summit level of Loch Oich, which was about 100 feet above the level of the sea; and accordingly, in addition to many heavy works which occurred in its course, there was at one point on the Caledonian Canal a succession of eight locks, by means of which a vessel of the largest class of merchantmen could be raised or lowered through a height of 60 perpendicular feet. The locks, which were in close succession, rose one above another, like a series of gigantic steps, and this unique and extensive marine ladder had not inappropriately been termed "Neptune's Staircase."

But without alluding farther to other important ship-canals, he went on to consider the improvement and maintenance of tidal navigations, which formed the sea accesses to the chief ports of this country; and without entering on other arguments in order to prove the importance of that branch of the subject, he had only to remind the Society that the trade of London, Liverpool, Newcastle, Glasgow, Dundee, and by far the greater proportion of the second-class ports, was solely dependent on the maintenance of the tidal

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[3] Smeaton's Reports, vol. i. p. 55. London, 1786.

[4] History of Inland Navigation, particulary those of the Duke of Bridgewater. London, 1766—Hughe's Memoir of Brindley, Weale's Quarterly Papers. London, 1843.

navigations, which, if he might use the expression, formed their only *highways* of communication with the ocean.

In introducing this subject, he would endeavour to explain what was implied in the word "tidal," as used in particular with reference to British ports, as he apprehended there was much more importance to be attached to the term than those who had not studied the subject were aware of; and he believed he would best explain this by drawing a comparison between Britain and some large tract of Continental country, such, for example, as North America. We there found capacious rivers extending for hundreds, he might say thousands, of miles into the interior of the country, and discharging an enormous amount of fresh water into sheltered and deeply indented bays—these indentations in the line of coast bearing, in fact, some proportion to the sizes of the rivers which flowed into them; and such a physical formation afforded facilities of no ordinary kind, not only for the establishment of safe harbours on the sea coast, without the expenditure of capital in their protection, but also for the extension of inland navigation to an almost unlimited degree, by means of the rivers themselves.

To give a practical idea of this, he stated that when he visited America, twelve years ago, he came to the conclusion, after examining the principal harbours on the sea coast which afforded most perfect shelter and a great amount of accommodation, that the formation of the smallest of our Post-Office packet stations in the Irish Channel had consumed a much larger expenditure of capital than the Americans have found it necessary to invest in the formation of harbour accommodation for trading vessels along a line of coast of no less than 4000 miles, extending from the Gulf of St. Lawrence to the Mississippi. With reference to the rivers which discharged into these bays, it was impossible in words to convey an adequate idea, or to describe the feelings which the traveller experienced, when, for instance, after crossing the Alleghany Mountains, and completing a fatiguing land journey from the eastern coast of several hundred miles into the interior of the country, he first came in sight of the river Ohio at Pittsburg. There, in the very heart of the continent of North America, he found a large shipping port, containing a fleet of between thirty or forty steamers, varying from 300 to 700 or 800 tons burthen, moored in the river; and his astonishment was still more increased if he chanced to witness the arrival of one of those steamers, and was told she had come direct from New Orleans in the Gulf of Mexico, and that fifteen days and nights had been occupied in making her *inland voyage* of no less than 2000 miles among the meanderings of the Mississippi and Ohio![5]

But Mr. Stevenson stated that with us the case was altogether different—the isolated and comparatively contracted limits of our country did not afford area for the collection of such bodies of fresh water. In proof of this, he referred to the comparative areas of the basins and the discharges of the different rivers, viz.:—

	Area square miles.	Discharge.
Thames	5,500	80.220
Tay	2,283	273.117
Clyde	1,270	94,000
Mississippi	982,400	24,600,000

Our streams could therefore, he said, be advantageously navigated only when their waters were deepened by the influx of the tide, and they were consequently closed to all vessels, excepting to those of the smaller classes, during the absence of tidal influence; and therefore our rivers, when compared to those of our Transatlantic or even Continental brethren, could only be regarded as narrow creeks or inlets, kept open by the joint action of the fresh-water stream and the tide; and as the action of the fresh water varied in its extent, and was at best but feeble, that our greatest stronghold in keeping open and deepening our navigations, must be sought for in the action of the tide, which not only scoured and maintained in a navigable state the sea channels of our rivers and estuaries, but also by its presence increased their depth of water. It was likewise, he said, to be noticed, that the fall or inclination of these large continental rivers has been found to be exceedingly small;—for example, the inclination of the Mississippi had been estimated to average, from its source,[6] ... per mile 3 in.

The Amazon	5
The Ganges	4
While the Thames was	21
The lower part of the Dee	11
The Lune	23
The Forth	13

The currents of the larger continental rivers were, therefore, more languid and more easily navigated, whereas the currents of our rivers were more powerful and less easily overcome. But here, again, an important advantage was derived from the tidal influence, which produced an upward current, by which vessels were enabled, without the aid of steam or wind, to reach their port; and he thought that was a view of the subject which could not fail to have struck the most superficial observer, when he saw on any of our navigable rivers or estuaries (such as the Thames or Mersey) a vast fleet of all sizes and from all countries, hurried on by the silent but powerful energy of the flowing tide. What an amount of latent power lay there! And how invaluable was that agency to the commerce of this country! If, indeed, the natural power latent in the *tides* of the Thames and Mersey were suspended, it might truly be said of the *steam* power employed on the net work of railways connected with London and Liverpool, that its occupation would be gone. Whatever, therefore, had for its object the improvement or maintenance of tidal navigations was, he submitted, of vast importance to the commerce, and entitled to the attention of our country.[7]

Mr. Stevenson then proceeded to explain that the chief obstructions to the propagation of the tides were the circuitous routes of rivers—the slopes of their beds—the projection of obstacles into their streams; and that the works by which these obstructions could be best overcome consisted in the deepening, straightening, and widening of the channels—the formation of new cuts—the erection of low rubble walls for the guidance of the currents of the first of flood and the last of ebb tide—the shutting up of subsidiary channels—and the removal of projecting groins. That the more rigidly that class of works was adhered to, the more generally beneficial would be the effect produced; for not only did they improve the part of the navigation where they were executed, but that their tendency was to increase the back water by which the sea channels were kept open. He then proceeded to illustrate these views by referring to the Tay, Forth, Ribble, Lune, and other rivers, where the duration of the tidal influence had been prolonged from 30 minutes to an hour, and the range of tide increased from 2 to 5 feet, while the navigation in all cases had been proportionally improved. Time did not admit of Mr. Stevenson's alluding to many other examples of importance, but the Clyde might be cited as a proof of the length to which such improvements had been carried. In 1755, Smeaton proposed to improve that river by erecting a dam across it with locks in the lower part of the river. In 1775, Golburn surveyed the river, and reported that, as far down as Kilpatrick, there were only 2 feet of water in it, but conceived that the river itself might be improved. In 1831 vessels drawing 13 ft. 6 in. came up to Glasgow, and now large vessels, three or four deep, are to be seen ranged along each side of the harbour. During 1834, 27,000 vessels passed Renfrew ferry, at some periods from 20 to 30 of them in an hour.[8] He next stated that, as an engineer could not form a design for such improvements without accurate data, it was of the highest importance to obtain correct information as to the tides, currents, and discharge of rivers, as well as the nature of their beds, and other particulars, and proceeded to explain how these data were obtained, and showed the different instruments for ascertaining the velocities of surface and under currents, and for procuring specimens of water from different depths; but for details on all these points referred to his treatise on marine surveying.[9]

He further referred to the plans of the Tay, the Ribble, Mersey, Dee, Lune, &c., to show that in each of these rivers there existed a large basin, or estuary, into which the tide flowed, and from which it was discharged twice in twenty-four hours, and stated that it was the flux and reflux of the large volume of tidal water from these natural basins which scoured the seaward channels, kept down the tracts of sand-banks by which their entrances were encumbered, and maintained a navigable depth of water over their bars. The instances to which he referred were all what were termed bar-rivers, or harbours, in contradistinction to such rivers as the Forth or Clyde, which had not similar obstructions. The fact of the existence of a strong tidal under-current was adduced to prove the effect of the flood-tide as a scouring agent, and it was stated, that while the fresh water, being specifically lighter, floated on the surface, the tidal current flowed in a stronger current below. He instanced, in proof of this, various examples, particularly the observations of Professor Traill and Captain Sabine on the Ori-

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[5] Stevenson's Sketch of Civil Engineering in North America London, 1838.

[6] Traill's Physical Geography. Edinburgh, 1838.—Johnston's Physical Atlas. Edinburgh, 1849.

[7] Stevenson on the Improvement of Tidal Rivers. London, 1849.

[8] Cleland's Statistical Documents—Transactions of British Association. 1836.

[9] Stevenson on the Application of Marine Surveying and Hydrometry to the practice of Civil Engineering. Edinburgh, 1842.

noco and Amazon[10] (the fresh water from these rivers being traced at a distance of 200 and 300 miles from the land), and also observations by Mr. A. Stevenson on the Cromarty Firth, where the velocity of the under current, at the depth of 50 feet, was ascertained to be at least double the velocity at the surface. The depths of water on the bars of the Mersey and Dee, Mr. Stevenson stated, were only about 11 feet at low water of spring tides—on the Ribble about 7—the Lune about 6—and the Tay about 16; and in navigating such estuaries, vessels must wait for the proper time of tide, either to leave or enter them. It would readily occur, therefore, that the maintenance of the depth of water over the bar was of vital importance to all ports situated within tidal estuaries. From a careful investigation of such localities, he thought it might fairly be stated, that, so long as the capacity of the receiving basins remained entire, no fear need be apprehended of a decrease of water on the bar; and this view he was the more inclined to believe to be correct, from the circumstance that, in several cases where he had occasion to compare the present state of some navigations with their condition as represented in the early charts of Mackenzie, the celebrated marine-surveyor, made upwards of half-a-century ago, he had found, that although the forms of the sand-banks and the direction of the navigable channel might have slightly changed, still there was no appreciable alteration in the depth of water on the bars; while, on the other hand, it had been pretty well established, particularly in the cases of Rye in Sussex, Southwold in Suffolk, and of Chester on the river Dee, and other places, that much injury had been caused by the embanking of land.[11]

The interests of proprietors of land along our rivers and estuaries, were often at variance with those of the conservators of navigation; and the endeavours made in many instances to protect and reclaim land were calculated, from being injudiciously and too extensively carried out, to be highly prejudicial, and hence arose the obvious necessity for some board of appeal between the interests of proprietors and those of the public—a power which was vested in the Lords Commissioners of the Admiralty, to whom, as conservators of navigation, we were indebted for the preservation of many of our harbours and tidal rivers. So important indeed was this subject considered, that, on the motion of Mr. Hume, the government, in 1844, appointed a Tidal Harbour Commission, to inquire into the state and condition of the harbours, shores, and navigable rivers of the United Kingdom, and to report what injury might have been done by encroachments or other interference with tidal waters; and, without detaining the Society longer, he thought he would best illustrate what is generally acknowledged to be the correct theory on this subject, by quoting the conclusion stated in the first report of that commission, which is as follows:—That "as a general, although not a universal principle, no cause has operated more extensively to injure the entrances of harbours throughout the United Kingdom than excluding the tidal waters from lands below the level of high water, which served as natural reservoirs for the flood tide, and were the means of affording a valuable scouring power during the ebb. Nor does any subject more deserve the vigilant attention of your Majesty's Government, or of those entrusted with the conservancy of our harbours, than such encroachments, which are usually made quietly and gradually, and when once completed, are difficult afterwards to remove."

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[10] El Maranam y Amazonas. Madrid, 1684.—Sabine's Account of Experiments to determine the figure of the Earth. London, 1825, p. 445.

[11] Reports of Tidal Harbour Commission.—Rennie's Reports on Hydraulics to the British Association.

REGISTER OF NEW PATENTS.

A SALINOMETER.

Andrew Peddie How, of the United States, but now residing in Basinghall-street, city of London, engineer, for "*an instrument or instruments for ascertaining the saltness of water in boilers.*"—Granted July 18, 1849; Enrolled January 18, 1850. [Reported in *Newton's London Journal.*]

The subject of this invention is an instrument called by the patentee a salinometer, by means of which the engineer is enabled to ascertain, at all times and under all circumstances, the density and consequently the saltness of the water in the boilers of marine steam-engines, independently of the pressure within the boiler.

Fig. 1, is a vertical section of the salinometer; and fig. 2, is another vertical section, taken at right angles to fig. 1. *a*, is a small cylinder, having at its lower end a projecting-piece, which is bolted to the side *b*, of the boiler; through this projecting-piece two passages *c*, D, are formed, leading into the pipes c^1, d^1, which terminate respectively at the upper and lower parts of the boiler; and the passages *c*, D, are provided with cocks c^2, D^2. *l*, is an overflow or waste-pipe, for carrying off all excess of water from the cylinder *a*;—*f*, is a cock for discharging all the water from the cylinder *a*, when desired; *g*, is an hydrometer, the graduated stem of which works through a hole in a fixed guide *h*; and *i*, is a thermometer.

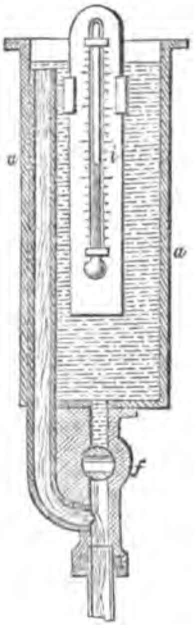


Fig. 2.

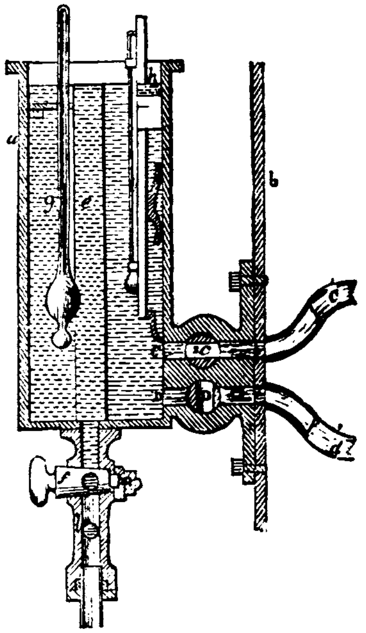


Fig. 1.

The action of the instrument is as follows:—Either the cock c^2, or the cock d^2, is left open (according as it may be desired to test the density of the water at the upper or lower part of the boiler), and the water passes from the boiler through the passage *c*, or D, into the cylinder *a*, and is discharged therefrom through the overflow or waste-pipe *l*; so that there is a constant flow of water through the salinometer of the same density as the water in that part of the boiler from which the supply is derived; and this density is ascertained by examining the graduations on the stem of the hydrometer. If the water, which is passing through the instrument, is derived from the upper part of the boiler, and it is desired to test the density of the water in the lower part thereof, the cock c^2, is to be closed and the cock D^2, opened; then the water from the lower part of the boiler will quickly drive out of the cylinder *a* (through the overflow or discharge-pipe), all the water that had previously entered from the upper part of the boiler; and the water which flows through the cylinder *a*, will then be of the same density as the water in the lower part of the boiler.

A thermometer is combined with the instrument, because the density or saltness of the water varies with the degree of temperature, and it is necessary to correct the indications of the hydrometer by those of the thermometer, as often as the temperature rises or falls beyond the standard point to which the hydrometer may have been graduated. Thus, supposing the hydrometer to have been graduated on the assumption of the water being at a uniform temperature of 200° Fahr., and that $\frac{2^\circ}{32}$ represents the density of the water at that temperature, the patentee finds that for every increase of 10° in the temperature of the water, one-eighth of a degree, or thereabouts, must be deducted from the amount of density indicated by the hydrometer; and for every decrease of 10°, one-eighth of a degree, or thereabouts, must be added. For example, if the temperature is increased to 210°, a deduction of one-eighth must be made on that account, from the $\frac{2^\circ}{32}$, which will bring the density to $\frac{1\frac{7}{8}}{32}$; or if the temperature is lowered to 180°, an addition of two-eighths must be made, which will make the corrected density $\frac{2\frac{1}{4}}{32}$.

The patentee does not strictly confine himself to the above details, so long as the peculiar character of his invention be retained. He makes no claim to the application of either the hydrometer or the thermometer to ascertaining the density or saltness of the water of marine steam-engine boilers; but that which he claims is, the peculiar arrangement, combination, and adaptation of means (each by itself well known) embodied in the single instrument above described, whereby the marine steam engineer is enabled, by the mere inspection of the said instrument, to ascertain, at all times and under all circumstances, the density of the water in the boiler, independently of the pressure within the boiler.

PLANING AND GROOVING MACHINERY.

William Edward Newton, of Chancery-lane, "*for improvements in machinery for planing, tonguing, and grooving boards and planks.*"—Granted October 5, 1849; Enrolled April 5, 1850. [Reported in the *Patent Journal.*]

The planing, tonguing, and grooving of planks or boards, as performed according to this invention, is effected by means of a separate series of tools, acting in a somewhat similar manner to the ordinary hand tools used by carpenters, their construction being also of a like character. These tools are fixed in a framework, while the board or plank to be operated upon is moved up by machinery to the work. The machine, as arranged according to this invention, consists of an endless belt or chain of plates, which form a table for the support and advance of the wood; this chain is formed of a series of narrow plates, linked together, the length of which form the breadth of the chain, and is sufficient to afford room for the greatest width of plank to be operated upon; these are linked together in the manner of an endless chain, and pass over two drums, one situate at the feeding-end of the machine, and the other at or about the middle of its length. The respective parts are supported by two principal side-frames, which carry the bearings of the before-mentioned drums. The axis of the central drum is driven by a train of spur gearing from the driving shaft, which is communicated to the chain by means of recesses in the periphery of the drum, into which the knuckle joints of the chain are received. These drums are placed, with their axes, in a horizontal position; the chain, while traversing the upper portion of its course, forming the table for the support of the wood; the plates of the table during this time rest at each end on the side frame, and are thereby kept in the same horizontal plane. A like endless chain is also provided, which is placed immediately above the other, and at the under line rests on the wood under operation. This chain is, however, considerably shorter than the other, the end-carrying drum of which is immediately over the lower end drum, and the other is disposed at about one-third the length of the frame from that end. The wood to be planed will thus be pressed between the two chains, the under chain however continues the support of the wood beyond the hold of the upper chain, and at which point the planing tools take effect. These tools are fixed to two cheek plates or frames, fitted on the two main wood frames, and form also the immediate support of the chain, as before mentioned. The drum of the upper chain bears in a separate frame, which is free to rise and fall, for the purpose of admitting the different thicknesses of wood to be planed This moveable frame is connected by two links, one on either side of the machine, placed in an inclined position, which, according to their incline, give a greater or less bite on the wood.

The upper chain being also driven, the tendency is to run off the wood, which is prevented by these links. The wood is fed in at the end of the machine, between these two endless chains, and as it emerges below the upper chain, at the opposite end, it passes below the planing cutters, which are a set of eight (more or less) double and single plane irons, similar to the ordinary plane iron, but of the full width of the machine. These planing cutters are set one behind the other, in such manner that each succeeding iron will cut a little deeper than the preceding one, and set at such angles that the rough outside may at one and the same time be operated upon with the smooth or finishing cut. On passing from under the planing tools, the wood is received on a stationary bed, on which it is held down by transverse rollers. The operation of tonguing and grooving then takes effect at the opposite end of the machine, for which purpose the wood, after being planed, is introduced between two sets of ploughing or tonguing irons, one set so as to take effect on either edge of the board The board is at the same time held down, or pressed by edge rollers; one set, together with one set of the cutting tools, are adjustable to suit the width of the board under operation. The rollers are fitted two on each transverse spindle, one roller at either end; the one being fixed, and the other moveable; while the cutters are held in a frame, sliding transversely, and moved by set screws, for that purpose. The cutting tools are similar to those ordinarily used for the purpose by carpenters, and placed at angles to the wood best suited for the purpose. Inclined or bevelled edges may also be prepared in like manner. Instead of the upper endless chain, to feed the machine, a set of weighted rollers may be employed, supported in a swinging frame, connected, as before explained, by the side links, in order to obtain the rise and fall, and to admit the different thicknesses of wood, together with the necessary bite on the wood, for the purpose of feeding it.

The patentee claims: First—The general arrangement of the machinery described.

Secondly—The employment of stationary cutting tools, combined with yielding-bar mouth-pieces, set forth.

Thirdly—Causing the top chain plate, or rollers substituted in lieu thereof, to press on the plank under operation, with a force varying with the resistance opposed by the cutting instruments, by altering the inclination of the connecting side-links described, for the purpose of forcing the plank under operation up to the cutting tools; and

Lastly—The use of adjustable edge rollers, to suit the different widths of wood, in combination with the tonguing and grooving, or other stationary cutters, as described.

IMPROVEMENTS IN VENEERING

Mr. John Meadows, of Princes-street, Coventry-street, has obtained a patent *for improvements in veneering*, which consist in effecting the union of the ordinary veneer in such manner, that it may be applied to irregular surfaces in one piece, instead of joining it at the angles and forming it in several pieces, as usual, which not only gives a great deal of trouble, but requires to be done to a nicety, and when complete, is unsightly, so far as regards the joints being always perceptible; and further, is very liable to get chipped or become detached from the article to which it is applied. In illustration of this mode of applying veneers, a number of ogee mouldings joined with several curved and flat surfaces, meeting at sharp or right angles, are shown in the drawings. A description of one of these will suffice for the whole. The frame or other piece of work to be veneered is prepared of the form required, which, supposing it to be first of an ogee form, the veneer is laid on a bed of that form, placed in a machine somewhat like an ordinary screw press. This bed is hollow, for the purpose of heating it by steam or other medium; pressure is then exerted by the screw on the frame, which is thereby pressed down on the veneer, and into the form required, between the heated bed and the frame or piece of wood to be veneered: so far, the process is very similar to that ordinarily adopted. The next surface presented, or that adjoining the ogee, is a hollow curve, meeting in a right angle the edge of the ogee; the veneer is of sufficient width to cover this, as well as any other portion of the frame service required. On the edge of the ogee bed a hollow bolster is hinged, having a hand lever, by which it is raised, so that the side presented to the veneer, which is of the curved form required, forces the veneer into the hollow, so as to effect complete contact with the whole of that surface; a suitable curved ratchet is provided, which sustains the bolster in its elevated position, the lever being such as to give sufficient pressure for the pnrpose; the veneer is thus bent over the angle and pressed into the curve. The next is a flat service, united by a right angle to the hollow. Another pad or bolster is hinged by a lever to the bed of the press, which is now raised and sustained by a click taking into a curved rack; the veneer is thereby bent over the succeeding angle, and on to the flat service, when the pad, to give the final pinch, is forced up by a screw; the pressure on the whole of the parts is allowed to remain until the adhesive material is sufficiently set for the purpose. The bolster and pad before mentioned have the levers and screws repeated at intervals, according to the length of the frame or surface to be acted upon. It will be obvious that other arrangements and forms of the parts will be required, according to the particular form to be veneered. Instead of employing ordinary glue for the purposes of veneering, according to this invention, the patentee employs parchment cuttings boiled down and mixed with whiting, to the consistency of paste, which is applied uniformly on the back surface of the veneer, the bed being at the same time wetted with a brush. The object of employing a white cement is, that the veneer, if thin, is not sufficiently opaque to hide the glue. An extremely thin sheet of brass is interposed between the veneer and the beds, and also a thickness of paper between that and the veneer; the angles are thereby better protected, and rendered sharper. Variations are produced in the forms of the beds, to suit other subjects to be veneered, by the application of paddings or filling pieces, to make up any or all of the parts to the figure required, by which one set of beds may suit a variety of designs of a nearly equal size.—*Patent Journal.*

REVIEWS.

Railway Economy, a Treatise on the New Art of Transport. By Dionysius Lardner, D.C.L. London: Taylor, Walton, and Maberly, 1850.

Dr. Lardner is commonly so happy in popularising any subject which he takes up, that he is the last man one would think of blaming for writing a book; but here we have book-making with a vengeance. To those who know nothing practically about railways, the book will pass muster; and of those who do, many will be deterred from objecting to it, because they are imposed upon by its appearance of mathematical and statistical labour. The mathematics put us very much in mind of the acquirements of the redoubted Hudibras:

> "For he could tell the time o' the day,
> The clock did strike, by algebra;"

to such a degree is the foppery of symbols carried; and there is a formula for everything. Thus at page 65:

"To determine the average number of miles run by each engine after such cleaning and lighting, it is only necessary to divide the total mileage of the locomotive stock, or of each class of it, by the total nnmber of engines lighted; the quotient will give the distance run by each engine lighted. In general, if E″ express the number of engines lighted, then $\frac{e+e'}{E''}$ will express the average distance run by each engine lighted.

"As examples of the application of this, we take, from the official reports of the Belgian railways, the number of engines lighted during 1846 and 1847. The number was 27,452 for 1846. Dividing this into the total mileage, 2,027,014, already given, the quotient is 73·8, which is therefore the average number of miles run by each engine cleaned and lighted.

"In 1847 the number of engines lighted was 30,676. We have already seen that the total mileage was 2,366,885. Dividing this by the number of engines lighted, we find 77·6 miles as the distance run by each engine lighted, being an improvement on the performance of the previous year."

The practical benefit of this in book-making is, first, the ignorant reader is led to imagine he gets something very good for his money; and, next, by making an algebraic formula—first, for the common operation of division, and by working it out arithmetically afterwards, so much more text is made in an easy manner. The statistics are of the same quality, and of the same value.

Although Dr. Lardner was employed some years ago in mathematical investigations connected with railways, he shows himself very ill-qualified for writing upon railway management. He seems to have stopped so long abroad as to have become Frenchified and un-Englished; and as he is without the practical experience, so he wants the documentary evidence as to railway management. His materials are the English blue-books—worth nothing; the two pamphlets of Captain Huish, the Belgian blue-books, and some French reports; and many French books: and he complains of the want of English statistics, whereas there is a whole body of English railway literature, and, above all, an extensive railway press. All the points Dr. Lardner opens, as he thinks, have been already discussed and settled, so far as they admit of settlement, by many able and practical men; and the railway papers afford invaluable data for the inquiries he has undertaken. The reports of the Committees of Investigation, in particular, afford most valuable information, of which our author has taken no advantage. Our own *Journal* has given information on these subjects to India and the United States; but it does not seem to have been of use to Dr. Lardner. Even the title of Railway Economy has been more successfully used by a Professor Gordon.

Inasmuch as the statistical results of English railway management are more favourable than those of French or Belgian, who are our pupils, it might have suggested itself to Dr. Lardner that our railway administrators are not so much in the dark as he intimates.

While the main body of the work is so unattractive, there is a very interesting chapter on American steam navigation, which, although much of it is trite, nevertheless contains some good matter; but altogether we wish the author had, for his own sake, been otherwise employed.

The title of the book is the best part of it, and that is 'Railway Economy,' which is very much sought after now: but no railway manager can learn anything from the book; nor do we think any shareholder can. Wherever a principle is sought to be established, that principle is limited in its application; and where a discovery is set forth, it is of something already known, and is working or tried, and found inapplicable. The writer has, indeed, missed the whole gist of the subject, or he might, with his popularity as a writer, have taken a very prominent and very useful part in the discussion of railway economy.

The history of railways has been one of progress; and to see it in its true point, and in its future bearing, it must be looked upon as of the same character. All is still new, and all will be innovation. The locomotive begun as a rude engine. Trevithick set it going with one cylinder: Stephenson strengthened it with two. It was still only a beast of burden, when Mr. Booth endowed it with the speed of a race-horse. The contests between the companies have called for an increase of speed; and this has been attained chiefly by an increase of bulk in the engine, and therefore of weight. It must not, however, be assumed that the increase of speed has been attained wholly by increase of weight; for it has been chiefly attained by improved mechanical arrangements, so that an engine of the old prize weight would still have increased speed and power of traction.

With a speed beyond all expectation and all calculation, the whole economy of railways has been altered; and a system has been gradually developed, which, by its development, has pointed out the successful means for superseding it. How we stand now is this: we have heavy engines, heavy rails, and, in continuation, heavy trains, unfrequent trains, great and distant stations, and great establishments.

Originally, it was considered railway traffic would, in its conditions, be like coach traffic—that there would be a succession of coaches, as it were, and station accommodation, was not contemplated. A train arrives, and a large establishment is requisite to attend to it, which establishment is empty-handed until the next train. A passenger comes to a bye country station, and, as he may have to wait some time, station accommodation must be provided for him.

Dr. Lardner's great doctrine is, to get rid of the "empties," and he might have extended it to empty hands; but although railway managers are quite alive to this, they cannot, under the existing system, carry it out; but rather, under the pressure of the times, they are aggravating the present state of affairs by lessening the number of trains—an economy which is attended by an injury to the traffic. The station expenses are now the most untractable items in the budget, and have been a heavy burden, particularly on new branches with a thin traffic.

In virtue of the progress of improvement, light engines and light trains, with a good speed, are now feasible, and we believe nothing stands in their way but the prejudices of the old locomotive manufacturers. We have now long advocated the adoption of the light system; and we are glad to see that its value is now more generally acknowledged, though we do not believe its full operation is adequately appreciated. In truth, the obstinate advocacy of fewer trains, in the teeth of all past experience as to traffic, is a proof of the carelessness even of those who are supporters of the new system. Notwithstanding, this system has now the assent of the whole body of the press devoted to railway polemics, of many engineers, and of many administrators; and, as it is already in practice, so must it go on to success.

While heavy engines were essential, large trains were likewise essential; and as these entailed a heavy permanent way, greater expense in the locomotive department, enormous stations, and large establishments, besides crippling and neutralising the expansion of the traffic by reducing the number of stations and departures, so do light engines allow of light trains, cheap permanent way, economy in the locomotive and carrying departments, a better distribution of plant and staff, cheaper stations, and more of them. By more frequent trains the plant will be closer worked—there will be fewer empties, and the establishment of the electric telegraph allows of a development of traffic which, ten years ago, was impossible.

From stations being now so far from each other, much local traffic is lost, for many a man finds it better to ride or drive, than go some miles to a station, and afterwards have a further journey to make from the arrival station to the place of his destination. We may confidently assert that, throughout, much railway traffic is at present lost, and that railway traffic is still in its infancy. Although there are traffic managers and goods managers, there is not one line which has a statistical department; whereas a competent statician should be engaged by each company to see what traffic there is in the district, how it is carried, what goes on the railway, what does not, and why not. The occasional exertion of a chairman or superintendent of traffic can never keep up with all the minutiæ of the many items constituting the carrying trade; for it is quite as much as such officials can do to attend to the daily working of the traffic under their control, which is their legitimate business.

Nothing but the light-engine system will diminish the margin of waste now constituting the expenditure of railways under the head of way and works, locomotive power, carrying, and stations; and the sooner the able men engaged in railway administration direct their attention to this, the sooner shall we have a diminished expenditure and increased traffic, and be able to do without those impolitic and pernicious expedients of raising fares and limiting the accommodation of travellers. Railway directors, who have generally risen from the ranks, nevertheless forget the circumstances of those classes who are not blessed with a superfluity of wealth. Every tradesman knows better than a railway director, and proceeds upon the principle of getting as much as he can from his customers by suiting his charges to their means in articles of daily necessity. The business of a railway director is to make as large a profit as he can, to carry on as large a trade as he can, and if he has not got trade to make it: but it is seldom he finds this out. The Metropolitan and Dublin Railways without suburban residences, Southampton without packets, Fleetwood without a harbour, the Midland Railway without coal and lime-pits, would fare but badly; and yet, in the teeth of this, how is railway development neglected! The Brighton steamboats have been burked, Sunderland Docks starved, the southern coal traffic kept back, the fish trade left to shift for itself, no attention paid to the carriage of building-stone and lime, and manure generally neglected. Horse traffic flourishes, the canals are in full vigour, and if railways have a large traffic, it is thanks to themselves, and not to their managers, who leave the trade to look after itself.

A Practical Treatise on the Construction of Oblique Bridges, with Spiral and Equilibrated Courses. By Francis Bashforth, M.A., Fellow of St. John's College, Cambridge. London: Bell. 1850.

Although works on oblique bridges are numerous, still one from the pen of Mr. Bashforth is welcome, as that gentleman is well known for his high mathematical attainments. The nature of the work, and the principles on which it is founded, are sufficiently described by the author. He says the methods in his first part are substantially the same as those of Messrs. Nicholson and Buck, but he has introduced numerous variations in the details. He prefers spiral courses for oblique bridges, because although grave objections may be urged, yet the accuracy of form which can be given to the archstones renders it advisable, under proper limitations, to adopt them in preference to a better arrangement of the courses, which does not admit of like exactness in the execution of the work.

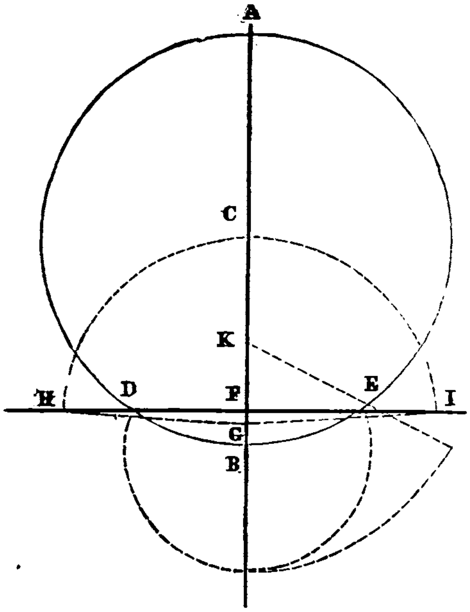
In Part II. Mr. Bashforth has endeavoured to give information on equilibrated courses in oblique arches, suited to the practical man; but we doubt if it be possible or desirable to initiate those concerned in carrying out the details in the elaborate analysis exhibited by the author. Mr. Adie, it will be remembered, was the first to construct oblique bridges of this kind, and Dr. Whewell and Mr. Sang have likewise written upon it.

The work is accompanied by numerous diagrams.

Railways in Ireland.—A return is just printed of all the moneys lent to railway companies in Ireland by the Exchequer Bill Loan Commissioners, and the amounts repaid. It appears that, from 1832 to 1842, the amount advanced to Irish railways was 157,200*l.*, and that the interest on such advance has been duly paid. Of the principal, 99,595*l.* has been repaid, and the remainder is in regular course of payment. From 1842 to 1849, there has been advanced to Irish railways, 834,000*l.*, chiefly within the last three years. There is no instance in which any arrears of interest are due. Of the principal, 51,179*l.* being the whole amount which has fallen due.

METHOD OF SQUARING A CIRCLE.

Sir—I send, subject to your approbation, the following description of a novel and ready geometrical method of *squaring a circle*, at once easy of application, and more approximate to the truth than any method yet proposed. The resulting square is only in excess of the true area $\frac{1}{65269}$th part; and the side of the square is in excess of the true side only $\frac{1}{130788}$th part; therefore being, for practical purposes, as accurate as the ordinary rule; side of square $=\sqrt{\cdot 7854 \times \text{square of diameter of circle}}$. The process is as follows.



Let ADBE be the given circle. Find DE, the side of a pentagon inscribed in this circle, and produce DE both ways to H and I. Let C be the centre of the circle, and AB be a diameter perpendicular to DE. From F (the intersection of AB, and DE,) set off (on AB) FG $= \frac{\text{CF}}{10}$; and with centre G, and radius GC, cut DE produced in H, and I. Then HI is the side of the square GEF.

I have assumed that the side of the pentagon can be readily found, either by angles, or by geometry. In the first case, make the arcs DB, BE, each equal to 36°; in the second case, I have employed a geometrical method which I have not met in any treatise or mathematical work, and which I find very useful. At B erect BL perpendicular and equal to the radius BC. Bisect the radius BC at K; and with centre K, and radius KL, cut AB produced in M; then, with centre B, and radius BM, cut the circle ADBE in D, and E. Join DE, which is the side of the pentagon required.

Demonstration.—Not to enter unnecessarily into a long explanation, it will suffice to state that if the diameter of the given circle be considered $=1$, then $\text{CF} = \frac{\sqrt{5}+1}{8}$, and $\text{HI} = 0{\cdot}886233701445\,\alpha$;

$$\text{But the true side is } = \underline{0{\cdot}886226925452\,\alpha};$$

$$\therefore \text{ the resulting side is } \quad 6775992$$

parts in excess in 886226925452; more concisely represented by the fraction, $\frac{1}{130788}$th part.

It may also be shown that the excess of area is nearly double that of the side, for $\text{HI}^2 = 0{\cdot}785410196624\,\alpha$;

$$\text{But the true area is } = \underline{0{\cdot}785398163397\,\alpha};$$

∴ the resulting area is 12033227 parts in excess in 785398163397; more concisely represented by the fraction, $\frac{1}{65269}$th part.

I think that I have succeeded in showing that this new and simple method is quite as practically accurate as the ordinary numerical rule, with which it also agrees to *four decimal places.* Numerical calculations are always troublesome to working-men, and a good geometrical method of reducing squares and circles has been long desired. As the method I now propose is easier, and more accurate than any previous ones, I shall be happy, through the medium of your *Journal*, to make it known.

J. B. Huntington.

ELLIPTICAL ECCENTRIC COG WHEELS.

Sir—Your Southampton correspondent, "William Davison," is perfectly correct in stating that Elliptical Cog Wheels may be applied with advantage to a variety of purposes, as I have practically proved such to be the case, having made and used them in the year 1840; being considered the first wheels of that shape ever brought under the notice of the public. I patented their application to the working of pump rods: the specification of which, is contained in the February number of the *Repertory of Patent Inventions*, for 1841; published by J. S. Hodson, 112, Fleet-street. But their principle of action is more fully treated on, in a publication that appeared the same year, intituled 'The Principles of Mechanism,' by Robert Willis, M.A., F.R.S., &c., Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge; published by J. W. Parker, West Strand, London. If Mr. Davison takes the trouble of referring to the above work last mentioned, he will find the diagram similar to his own, at page 240.

Ryde, Isle of Wight, JOHN G. DASHWOOD.
April 19, 1850.

PROGRESS OF THE BIRKENHEAD DOCK WORKS.

The dock works as viewed from the river seem unfinished and ruinous; but proceed inland to the western end of the Egerton and Morpeth Docks, and a scene of activity bursts upon the view, which it is not easy to parallel. From this point a dam has been carried across to the opposite side of the pool to pen up the waters of the upper portion of the proposed great float; and here, under the spirited contractor, Mr. M'Cormack, twelve hundred men are working night and day, excavating the mud and earth to form a dock which, as at present determined, will extend to the copper works on the Seacombe side of the pool, and give a water area of fifty acres. A further extension, however, is contemplated, which will carry the dock, or float, as far as Poulton bridge; and the contracts for this extension have been advertised for.

The depth of this dock adjoining the quays will be eight feet below the level of the old dock sill of Liverpool, or six feet lower than the bed of any of the docks of our port. The centre will not be excavated quite so deep. A portion of the walling at the Victoria Wharf, which runs at an angle from the dock warehouses, is already completed, and is of excellent and solid workmanship. Another portion, fronting the warehouses, is rapidly advancing. The excavations in the centre of the dock are progressing at a speed which, considering the immense area over which the labour employed is spread, is surprising. Every appliance of mechanical skill, and of steam, is, of course, provided by Mr. M'Cormack in aid of the human labour employed. Two steam engines of thirty horse power each lift the wagons of earth from the bed of the dock to the place of deposit; and more are being provided as the works progress.

The entrance to the float from the Egerton Dock is nearly completed, requiring now only to be smoothed to fit the gates. Those for the inner end of the gut are to be seen in the carpenters' shed adjoining the work, and are of immense strength, and splendid workmanship. They are, moreover, the largest in the world, being 70 feet wide, and show that the Birkenhead Dock Commissioners have had their eyes open to the fact that we may, in all probability, have shortly to accommodate in the Mersey vessels of much larger tonnage and breadth of beam than heretofore. The gate next to the float is to be constructed as a caisson, to be moved altogether, and rest, when open, in a recess made in the dock-wall. The main timbers for this work are also prepared, and are formed of pieces of oak, dovetailed and morticed in, so as to increase their strength, and at the same time prevent deflection.

The gut leading to the tunnel, by which the outer entrance to the dock is to be scoured, is also completed, with the exception of a little smoothing of the sill to ensure the fitting of the sluice-gate. The tunnel is fifty feet wide, and about thirty in height, and through it will pass, when the sluice is opened, a large body of the water in the upper float, which will be refilled to its proper level by the drainage brought down from Bidston marshes. When it is borne in mind that this is spread over the large area of 50 acres, its effect, when compressed, and flowing through an arch of only 50 feet in width, must be to give a most tremendous scouring power.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

INSTITUTION OF CIVIL ENGINEERS.

March 26.—WILLIAM CUBITT, Esq., President, in the Chair.

The first paper read was a "*Description of the Chapple Viaduct, upon the Colchester and Stour Valley Extension of the Eastern Counties Railway.*" By Mr. P. BRUFF, Assoc. Inst. C. E.

This viaduct was thrown across the valley of the Colne, at Chapple; it consisted of thirty-two semicircular arches, each of the span of 30 feet, the total length being 1136 feet, and the extreme height from the foundations to the rail level being 80 feet. The average height of the piers from the foundation to the springing was 45 feet; they were 27 ft. 3 in. wide by 4 ft. 10½ in. thick, at the under side of the impost, and tapered downwards to the plinth, with a batter of 1 in 36; twenty-three of the piers only had plinths, which, consisted of a set-off of 2¼ inches, making the dimensions of the base of the piers 29 ft. 6 in. wide, by 7 ft. 1 in. thick. The piers were solid below the plinth, but above that level there was a centre opening 6 feet in width, arched at the top and the bottom. The whole of this viaduct was constructed of bricks made in the district, being chiefly set in mortar, but the arches for a distance of 4 ft. 6 in. above the springing were set in cement. The viaduct occupied about twenty months in construction, and cost about 55*l*. per lineal yard.

The next paper read was "*On the Manufacture of Malleable Iron, with the results of Experiments on the Strength of Railway Axles.* By Mr. G. B. THORNEYCROFT, Assoc. Inst. C E.

It was stated that malleable iron might be divided into two distinct classes, "red short," and "cold short;" the former being generally produced from the rich ores, and the latter from the poorer, or leaner ores. The pig iron made from the rich ores (under the cold blast process only) was not so fluid as that from the lean ores, but when converted into malleable iron it became tough and fibrous, though it was troublesome to work at less than a white heat, which had caused it to be denominated "red short." On the other hand, the pig iron produced from the lean ores possessed greater fluidity, but when malleable it was unfitted to support sudden shocks, or continuous strains, and was hence termed "cold short." It was further stated, that in the manufacture of malleable iron very much depended on the quality of the fuel used in the smelting furnace, and in the subsequent processes; also that iron became crystalline from two causes; first, in consequence of being made from naturally cold short pig iron, and secondly, from a peculiar manipulation during the process of "puddling."

The introduction of hot blast for smelting iron, rendered necessary a careful investigation of the comparative use of hot and cold blast pig iron, in the manufacture of bars, from which it appeared, that if the same quality of materials was used in both cases, equally good bar iron would be produced, though it was more difficult to convert hot blast pig iron into "No. 1" bars, and the waste was greater. It was certain, that whilst good grey pig iron could only be produced, by cold blast, from the best materials, iron of apparently excellent quality could be made, by hot blast, from the most sulphurous ores and fuel; indeed, to this alone must be attributed the bad reputation of hot blast iron, for certain purposes.

As it had been asserted that the peculiar characteristics of malleable iron were to be attributed to the ore from which it was produced, and not from the different nature of the processes used in its conversion, which the author had always believed to be the true cause, he had, at his works near Wolverhampton, made bars of the finest crystalline and of the strongest fibrous texture from the same Yorkshire pig iron. Another cause which induced great changes in the texture of iron, when cold, was compression, or impact, which would completely alter its texture from a fibrous to a crystalline character, as was well exemplified by the "gag" and the puddling tools used by forgemen, and in several parts of different kinds of machinery the same effect was observed.

The author then proceeded to draw attention to the best shape for railway axles, so as to combine the greatest strength with the least material, illustrating his views by the details of a series of experiments made for determining the question. It would appear that railway axles should be made parallel, from journal to journal, without any shoulder, and with just sufficient strength to prevent any vibration in rotating. The experiments showed, that an axle without a shoulder was better able to resist impact than one with a shoulder, in the ratio of 155 to 55, and by leaving the axle parallel, its strength, compared with the same sized axle reduced in the middle, was 5 to 1½.

April 2.—In the renewed discussion upon Mr. Thorneycroft's paper, it appeared to be admitted, that the shoulder on axles was only useful as a gauge, and that it should be curved from, and not square to, the main body;—that between the journals the axle should be parallel, for if reduced in the centre it was sure to bend, and eventually to break. Since the last meeting Mr. Thorneycroft had made many other experiments, which proved his former opinion relative to the progressive changes in iron, from compression, which alone caused the destruction of the fibre, and, in fact, that jarring would not do it. Experiments were suggested to ascertain whether a pressure on the periphery of a wheel, fixed on an axle and kept rotating, would produce the same results which were admitted to exist in practice.

The paper read was a "*Description of a Lift Bridge, erected over the Grand Surrey Canal, on the line of the Thames Junction Branch of the London, Brighton, and South Coast Railway.*" By Mr. R. J. Hood, M. Inst. C. E.

The act for the construction of this branch, which was a single line, one mile in length, provided that the crossing of the Grand Surrey Canal should be by a swing bridge; but as there were many obstacles in the way of this clause being carried out, and as it was not thought to be the most convenient form of construction, it was determined, after due consideration of the advantages and disadvantages of each particular kind of moveable bridge, to erect one on a principle which might be designated a "lift bridge." This consisted, simply, of a rectangular platform, 23½ feet in width, and 35 feet in length, carrying on one side a line of rails, and on the other side a roadway for carts; it was formed of four beams of oak timber, undertrussed with wrought-iron rods and cast-iron saddles, those for carrying the rails (which were bridge-shaped), being stronger than the others, and having a flooring of 3-inch planking; the platform rested, when down, upon piles driven into a bed of hard gravel, met with at a depth of about 20 feet below the water line. The platform, which was about 12¾ tons in weight, was suspended at the four corners by galvanised wire ropes, four inches in circumference, attached to the end of each oak transome, by means of strong bow springs, and passing over pulleys fixed on four pairs of cast-iron standards, also supported on piles, and fastened at the other end to drums, 3 feet in diameter, each pair of which were keyed on to the same horizontal shaft, situated a few inches under the rail and road level. Upon the same shafts there were also fixed six other drums, of a like diameter with the former, carrying, upon coils of wire rope, 2⅝ inches in circumference, balance weights, of a total weight of 12½ tons, but not equally distributed, intended to assist in raising the platform, and which descended in cast-iron cylinders, or wells. Motion was given to one end of each shaft, by means of simple hand-gearing, consisting of a train of wheels and pinions, by which the power was multiplied twenty-six times.

The level of the rails, above the water-line, was 4½ feet, and as the platform was capable of being raised 9⅞ feet, sufficient room was afforded for the passage of the barges, the greatest number of which ever passing through in the twenty-four hours being fifteen, and since the erection of the bridge, not one in a hundred had been detained one minute; though on this point, as well as on many others, the Canal Company had raised factious objections, owing to which, and to the design having to be submitted for approval to the Railway Board, great delay arose in the commencement, and also in the execution of the work, augmenting the actual cost to 1,300*l.*, which was beyond what, it was presumed, a similar work could, under more favourable circumstances, and when the construction was not novel, be executed for.

The bridge was stated to have proved very successful, and in situations where only a given headway was required for a limited span, this kind of construction was recommended.

April 9.—The paper read was "*On the Construction of Locks and Keys.*" By Mr. J. Chubb, Assoc. Inst. C. E.

The author commenced by stating, that the most ancient lock, of whose form and construction there was any certain knowledge, was the Egyptian, which had been in use for upwards of four thousand years. The construction of this lock was minutely described, also that of the ancient "warded" and "letter" locks, and considerable antiquarian research was displayed in tracing their origin and introduction. These three kinds of locks were, in principle, the foundation of all modern locks, which might be thus enumerated, reversed, for obvious reasons, in their order of antiquity:—

First,—The letter locks; mostly used for padlocks, and were so far convenient, as a key was not required for opening them. A modification of this lock had been proposed, called the "scutcheon" lock, for securing doors and iron safes, but it was too expensive and complicated to come into general use.

Second,—Locks having fixed wards, in which no real improvement had been made in modern times. These locks were bad in principle, as they could be easily picked; and owing to many thousands of them being yearly made, that could be passed by the same key, little or no security was afforded by them; in fact, it might be safely asserted, that twenty skeleton keys would open all the locks, of a given size, made upon this principle.

Third,—The Egyptian lock; the essential principle of which was, that of moveable pins, or studs dropping into, and securing the bolt, all of which must be raised to the proper height, by corresponding pins in the end of the key, before the bolt could be unfastened. This lock was the foundation upon which most of the ingenious inventions of late years had been based, differing only in the forms of the moveable obstructions to the bolt—some of which acted vertically, others horizontally, some with a rotatory motion, and many others in an endless variety of ways; but of all these it was thought sufficient to describe only those best known and appreciated—namely, Barron's, Bramah's, and Chubb's.

In Barron's lock, patented in 1774, a great improvement was made upon the ancient Egyptian, by the introduction of the over-lift, wards being also used; but, from the fact of there being only two tumblers, it was evident that no great change or permutation could be made in the combinations.

In Bramah's lock, patented in the year 1784, there was a compound of both direct and rotatory motion given to the key, instead of simply the latter, as in Barron's lock. It consisted of a number of sliders, having notches of various depths cut on one edge, so that the motion of the bolt was totally prevented, until each slider was pressed down to its exact depth, which was effected by the key having six cuts in it of different lengths.

In Chubb's lock, first patented in 1818, and since modified and improved by various subsequent patents, there were six separate and distinct tumblers, placed over each other, and capable of being elevated to different heights, but all moving on the centre pin. This lock differed from the others, in having a "detector," by which any attempt to pick, or open the lock with a false key, was immediately notified on the next application of its own key.

Calculations were then gone into, to show the number of different combinations which might be made in this lock; and it appeared, that with an average-sized key, having six steps, each capable of being reduced in height twenty times, the number of changes would be 86,400; that if the seventh step, which threw the bolt, was taken into account, the reduction of it only ten times would increase the number to 864,000. Further, that as the drill-pins of the locks, and the pipes of the keys, might be made of three different sizes, the total number of changes would be 2,592,000. In keys of the smallest size, the total number would be 648,000, whilst in those of the largest size it would be increased to 7,776,000 changes.

In conclusion, it was stated, that the manufacture of locks and keys was principally carried on at Wolverhampton and the adjacent towns, Birmingham, and London, and that the fundamental principle upon which all locks should be made, were perfect security—strength, so as to resist attempts to force them, or of opening by picklocks and false keys—simplicity in the arrangement, so that any stranger, having the proper key, might be able to open the lock—and durability.

The paper was illustrated by a series of diagrams, and a variety of specimens of the locks and keys noticed in the paper; and also by a number of Gothic locks and keys of very elaborate workmanship, suitable for ecclesiastical buildings, &c., from Mr. Chubb's works, in London.

In the discussion which ensued many additions were made to the historical part of the subject, and various ingenious contrivances were described, which had been successfully applied, to give increased security to locks of ordinary construction. The combinations in the locks of Summerford, and McKinnon (of New York), were also fully described; an advantage being claimed for the former, in making one tumbler to lift and the other to fall, in order to open it; and, for the latter, that, by the addition of a curtain, of case-hardened iron, three-quarters of an inch in thickness, radiating from the centre of the pin, and a radiating key, there were no means of reaching the tumblers, for the purpose of taking an impression, or otherwise, except by cutting through that curtain. On the other hand, it was positively asserted, that no impression could be taken of, or means invented for picking, a lock which had six tumblers, although it could be easily done with locks having fixed wards; further, that Chubb's lock was a decided improvement on all others of the same character, inasmuch as it possessed a "detector," which formed really the peculiar feature of that lock; the excellence of the workmanship tended also to the facility of action and consequent durability, for which it was so celebrated.

April 16.—The discussion upon Mr. Chubb's paper, "*On the Construction of Locks and Keys,*" was renewed, and extended to such a length as to preclude the reading of any paper.

Several locks which had not been previously mentioned, were exhibited, and their peculiarities of construction were described. These bore the names of their inventors—Davis, Parsons, Williams, and Nettlefold.

It was urged, that the curtain which had been mentioned might be essential for Summerford's lock, but could not be, in any degree, useful in Chubb's lock; in fact, that its only effect would be to induce complication, and augment the cost, without increasing the security.

Among numerous instances of ingenious devices for opening locks, that stated to have been tried in America excited much attention. The process was described to be, that the operator, after inserting two pieces of India rubber, to limit the sphere of action, injected from a force-pump a composition of glue and molasses, in a heated state, which chilled quickly, and, although extremely elastic, had the property of retaining the form and position of the lower side, or bellies of the tumblers, and that after being cut out of the lock, by a thin-bladed instrument, a key could be made from the impression.

In explanation of this, however, it was shown, that in Chubb's lock there existed no similarity between the position of the bellies of the tumblers, when at rest, and the figure of the bit of the key; and, therefore, that even supposing it to be possible to obtain an accurate impression of the position of the bellies of the tumblers, when at rest, no indication would be afforded of the combination, or any assistance be given for making a false key. In further confirmation of this, a lock by Chubb was shown, in which, when at rest, the bellies of the tumblers were perfectly uniform, and in the same plane, so that an impression of the inside of such a lock must be utterly useless for any purpose.

Although it had been asserted that Chubb's locks had been picked, it was admitted that it had never been proved that those locks had really been made by the inventor; but, on the other hand, it had frequently been shown that purious imitations of the first expired patent had been sold in large quantities, and had been marked "Chubb's Patent," until the makers were stopped by legal process, when it was ruled, both at law and equity, that, although after the expiration of a patent, any person might manufacture the article, he had no right to pirate a peculiar trade mark, or to use a distinctive stamp, which was irrespective of any patent right.

The locks used at Pentonville Prison were instanced as uniting goodness and safety with extreme cheapness; but it was admitted that the workmanship was very inferior to that of Chubb's locks.

It was also asserted that Davis's locks, invariably used on the Cabinet Dispatch-boxes, which frequently contained important secret papers, were never found to be out of order, or to be susceptible of being picked.

To this it was replied, that Mr. Chubb was prepared to produce a workman, who, without having ever previously seen the locks on the Cabinet Dispatch-boxes, would open any number, on being allowed half an hour for each; and that the same might be done more easily with the Pentonville Prison locks.

In summing up the discussion, it was stated to be the duty of the Institution to express the conviction, of a veritable Chubb's lock never having been picked either in Great Britain or on the other side of the Atlantic; that it did, in fact, combine that strength, simplicity, and security, without which the most ingenious locks were utterly useless; that it possessed the merit, in the production, of never, through fear of competition, having reduced the quality of the workmanship to meet a reduced price, and thus, by a due consideration of the workmen employed in the manufacture, the men had been taught to be as jealous of their master's reputation for good work as he could be of himself, and that thus the merited reputation of the work had been, and was still, maintained.

April 23.—The paper read was a "*Description of the Insistent Pontoon Bridge, at the Dublin Terminus of the Midland Great Western Railway of Ireland.*" By Mr. R. MALLET M. Inst. C.E.

This bridge was stated to be situated on the line of approach from the city to the terminus, and formed a passage over one branch of the Royal Canal, where it crossed the Phibsborough-road, upon the Foster Aqueduct. By the act it was provided, that the navigation of the canal should be as free and unimpeded as possible; and from the circumstance of there being only a height of 16 inches between the intended surface of the road and that of the water of the canal, it necessarily involved the placing of some kind of moveable bridge, of rather peculiar construction. After due consideration, the one described in the paper was designed and adopted, as being more suitable to the peculiarities of the situation than any other, owing to the water-channel being only 17 ft. 4 in. in width, and that the passage to be made across it required to be at least 50 feet in breadth.

The general idea of this form of moveable bridge was that of a pontoon, or flat-bottomed boat, constructed of iron; the breadth being nearly equal to that of the water space to be crossed, and the length about equal to the width of roadway required. The deck beams of this pontoon projected over the sides, and rested while *in situ*, upon a rabbate, or continuous recess, formed along the top course of each quay-wall, but while the pontoon was floating light, the projecting deck-beams were 2 inches clear of this rabbate, and the roadway platform, constituting the deck of the pontoon, was elevated to an equal height above the level of the top of the quay-walls, or land on each side; in this state the pontoon could be freely and readily pushed along the canal, for a distance of rather more than its own length, until it was brought opposite to a lye-by, provided by increasing the width of the canal at this point, and being put therein, the navigation was perfectly free.

As a pontoon afloat would form a very unstable roadway for carriages, means were provided for allowing it to settle down in the water, and rest firmly upon the rabbates; and also for again raising it rapidly, so as to float clear of the rabbates, and enable it to be moved away into the lye-by. For this purpose two large valves were placed in the bottom of the pontoon, one near each end, by which water was allowed to enter, and sink the pontoon, until it hung upon the projecting deck-beams. For removing this water, when it was required to float the pontoon, a large syphon, of a particular construction, was provided, which was capable of being brought instantly into use, and of being as quickly detached, when a sufficiency of water had been withdrawn to enable the pontoon to be moved. These operations were stated to be performed very readily by one man, the navigation being cleared in four minutes, and the roadway restored in less than three minutes.

The details of the construction of the pontoon, of the syphon, and all other parts of the work were then minutely given; also the total cost of the structure, which, exclusive of the masonry, was 1125*l*., that of the masonry being about 150*l*.; and it was stated to have continued in use, with perfect satisfaction, since its completion in February, 1847.

This form of construction was considered to be applicable in situations where a comparatively narrow water channel had to be crossed by a very wide roadway; but as the particular circumstances of other localities might differ from the one in question, the author suggested various alterations in the details, so as to meet these exigencies.

The next paper read was a "*Description of a wrought-iron Lattice Bridge, constructed over the line of the Rugby and Leamington Railway.*" By Mr. W. T. DOYNE, Assoc. Inst. C.E.

This bridge, which was 150 feet span, carried a public road over the Honingham cutting. It consisted of two girders 156 feet in length, and 10 feet 6 inches in depth, placed at a distance of 20 feet apart, and connected together by means of wrought-iron transverse girders, and by a system of horizontal diagonal bracing. The bottom of the main girders were formed of two angle irons, and wrought-iron plates, eight in number at the centre, but diminishing to three at the ends, and of such dimensions as to make the effective sectional area at the centre, after deducting the loss by rivet holes, equal to 26 square inches; that of the top, which was somewhat differently constructed, so as the better to resist compression, being equal to 40 square inches. The lattices were formed of a series of bars of spoke-iron, intersecting each other at an angle of 60°, being crossed at those points, by longitudinal bars, for the purpose of giving additional rigidity, and of making a closer parapet. The transverse girders, 7 feet 6 inches apart, were each formed of a plate of wrought iron, with two angle irons at the top and the bottom; these were covered with corrugated galvanised iron, one-tenth of an inch thick, upon which concrete, and then a layer of gravel and loam metalling, 6 inches thick, were laid. This bridge was erected by Messrs. Smith, Smith, and James, of Leamington, upon a platform which gave to the girders a camber of 7 inches in the centre, which was reduced to 3⅜ inches upon removing the platform. The total cost of the bridge was about 3,500*l*.

During the progress of the works, the author made some experiments upon the strength of rivets of different sizes, from which it appeared, that the average breaking weight, per square inch of sectional area, was 35·10 tons for a chain joint, and 18·82 tons for a lap joint.

ROYAL SCOTTISH SOCIETY OF ARTS.

The following communications were made:—

Remarks on the Positions laid down by Mr. Cousin, in a Communication lately read by him, "*On the Philosophy of the Beautiful, and an Analysis of the Principle of Proportion, as applicable to Architecture.*" By Mr. THOMAS PURDIE, Edinburgh.

Mr. PURDIE stated the principle on which Mr. Consin seemed to found his doctrines, viz.—that the mind receives a pleasure from certain proportions, whether in the relations existing between the various parts of a building, or in the relations which the notes of a musical chord bear to each other in the number of vibrations required to produce them. That harmony is, therefore, "the perception of these relations," conveyed to the mind in the one case by the eye, and in the other by the ear.

Mr. Purdie contended that this definition of harmony was only a confounding of names. That the word harmony is applied to architecture only in a conventional or metaphorical sense, and may therefore be used to convey any meaning which fashion or fancy may happen to dictate. But, whatever harmony in architecture may be, the mind which perceives nothing and knows nothing of the relations of musical notes or of vibrations may receive a pleasure from harmony of the most intense and elevated kind. While the secondary beauty of harmony is, doubtless, due to its connection with man's deepest feelings and most interesting emotions, its primary beauty can be attributed only to sensation as an ultimate fact in man's mental constitution, and has no more connection with perception of relation than have the prick of a pin or the perfume of a rose. If there were any beauty at all in ratios, the ratio existing between the diameter and circumference of the circle seemed to possess quite as much of that desirable quality as the ratio of one to two, or three to four. If harmony, he contended, were the perception of relation, and if those relations only were beautiful which are simple and definite, what would have become of the mathematician engaged in the higher calculus where many of the calculations refer to irrational and even imaginary quantities. A single page of it would evolve an amount of discord sufficient to drive altogether mad any mathematical devotee who might happen to be cursed with a musical temperament.

But granting that Mr. Cousin had established the premises—that harmony is the perception of relation, and that beauty results only from the perception of definite relation—he had only placed his doctrines in a position which rendered their complete fallacy the more obvious and apparent.

Take any number of rectangular forms such as those to which it is proposed to apply this system of proportioning—say two windows of a building with the space between them. Adopt some of those ratios which Mr. Cousin asserts to be beautiful, and apply them to the diagonal lines of these rectangles. Let the diagonal line of the windows form with the base an angle of 60 degrees, and that of the space between them 67½. These numbers, if the angles be taken as the standard, bear a simple or harmonic ratio to each other, and to a right angle. But it is impossible to suppose that the relations of angles, formed by unseen diagonal lines, which are supposed to be drawn within certain rectangular figures, can serve as the foundation for a system of proportion, or that they can produce so powerful an effect as the relation between the sides, which are visible to the eye; and, unfortunately for this theory, it happens that the sides must of necessity be at variance with Mr. Cousin's proportions in every case, when the angles are in accordance with them.

In the designs exhibited to the Society, Mr. Cousin, for the most part, adopted the angles as the basis of his harmony; but he sometimes admitted the proportion of the sides, and at other times he admitted of both in the same elevation. Granting, then, his definition of harmony to be correct, no building could possibly be beautiful; for the eye, which was gratified by the simple ratio existing between the angles, must also perceive and be offended by the want of these so-called harmonic proportions in the sides.

Mr. Purdie farther objected to this theory on the broad ground that it involved the setting aside of taste altogether; that it was calculated to erect within the dominion of taste a tribunal to overrule and supersede its judgments. If any one were to object to a building of Mr. Cousin's, or of any other architect, designed on the principles brought before the Society as being ill-proportioned, it could be no answer to tell him that this was an angle of thirty degrees, that of forty-five, and so on. Unless the jurisdiction of this theory were to be supreme, the architectural critic would have a full title to hold to his opinion, notwithstanding these so-called mathematical demonstrations. But as the explanations which the discussion on Mr. Cousin's paper called forth, at a late meeting of the Society, had placed the matter on a very narrow ground, Mr. P. preferred to leave it there, rather than enter upon matters which could only lead to endless and perhaps altogether unprofitable discussion.

Observations on what is required to be done, in order to improve the Dwellings of the Working-Classes; with a brief notice of some Model Houses recently erected in this neighbourhood, and some account of those which have been built in London, Glasgow, &c. By PATRICK WILSON, Esq., Architect.

Mr. WILSON observed, that in looking at the large tenements in the centre of Edinburgh, occupied by a prodigious number of families, some of them elevated six or eight stories from the street, it must appear almost an impossibility for such families to have anything like cleanly dwellings; the common stair of such tenements is, in general, in such a state of filth, that there is no inducement to the housewife of cleanly habits to attempt keeping a clean house. He, therefore, contended the working-classes must be placed in self-contained houses. Such an idea might at first sight appear Utopian, but so far from this being the case, it had actually been realised, and that at a rent not exceeding what is paid for the same accommodation in other situations.

Mr. Wilson then took a rapid glance at what had been doing in other towns. He gave some brief account of the houses recently erected in London; but in general remarked that they could not be taken as a guide for us in Edinburgh, the rents paid for them being far beyond what could be afforded by Edinburgh operatives.

Mr. Wilson laid before the Society the plan which had occured to himself sometime ago for improving the dwellings in question, which he had since had opportunity of carrying into practice. To effect this on the most economical plan, he proposed having houses of two stories high, the houses on the first floor to have their entrances on the one side, and those on the second floor on the other side; and further, that rows of such houses should be placed at *right angles* to the road or street.

There are six rows of houses, each row containing eight houses, four on the ground-floor and four on the second floor. The spaces of ground between the rows are devoted for bleaching-greens, with the exception of a *footpath* on each side leading to the houses. The Model houses recently erected at Industry-lane, North Leith, under the superintendence of Mr. Wilson, are built on this plan. The piece of ground at Industry-lane only admitted of two rows: one is built, and the houses are at present being finished, the other is in contemplation to be built. The houses are of various sizes. The average size contain, one large living room or kitchen, one bed-room, a scullery sufficiently large for the mistress of the family washing in, well lighted, and furnished with sink and water-pipe, and a pantry. The sculleries are placed two and two together, not only so, but those on the lower floor being immediately under those on the upper floor; there are four sculleries all in a cluster, which arrangements, besides the economy, possessed other advantages which Mr. W. pointed out. With the exception of the water-closet, each house possesses every convenience within itself. The water-closets are placed out of view at the farther end of the row, and under lock and key. The apparatus for these closets are of the most simple construction; one cistern supplies the whole cluster with water.

The largest size of houses at Industry-lane contains a large kitchen, two bed-rooms, and the other conveniences already described. These were commodious houses, and what in Mr. Wilson's opinion, every house should be, provided those for whom they are intended could pay a proportionate rent. The parents and younger branches would be accommodated in the large apartment, the boys in one room, and the girls in the other.

The houses at Industry-lane are all let at the following rents:—Two houses at 5*l.* 5*s.*; two houses at 6*l.* 6*s.*; two houses, each with two bed-rooms, at 7*l.* 15*s.* Total receipt, 51*l.* 4*s.* Cost of the eight houses, 700*l.*, 5 per cent on which is 35*l.*; feu-duty, or ground-rent, 3*l.* 5*s.* 6*d.*; making a total outlay of 38*l.* 5*s.* 6*d.*; and leaving for taxes, repairs, &c., a margin of 12*l.* 18*s.* 6*d.*

A considerable portion of ground has been feued at a very moderate rate, through the kindness of Mr. Balfour, of Pilrig, and on which it is intended to erect houses somewhat similar to those at Leith.

Description and Drawings of a new Patent Air-Spring for Shutting Doors and Gates, opening one or both ways: with a narrative of the Patentee's Experiments in arriving at the best arrangement. By Mr. GEORGE BEATTIE.

Mr. Beattie stated that in this new Patent Spring Hinge the pressure of the atmosphere is employed for the motive power to close the door. That it is not a spring properly so called, but simply a counterbalance, by means of the pressure of the atmosphere made to act towards a vacuum, the resistance being uniform throughout the travel of the door, which combines comfort, safety, and durability. The air spring consists of an iron box and cover let into the floor, which contains a verticle axle supported at bottom in a hollow cup, and furnished at the top end, which projects above the floor, with a shoulder and lever hinge for carrying the door on this shaft, and within the box is fastened a horizontal wheel, which is toothed upon a portion of its circumference. On each side of this wheel is a rack attached to a piston, which is made to fit tightly into a cylinder by a cap leather. In the under side of the cylinder is a valve communicating with the outside; in the bottom of the cylinder is another valve communicating with an exhausted chamber, and on each side of the racks are guides for the piston. The teeth of the wheel are made to take in either of the toothed racks, according as the door or gate is opened one way or other, so that the piston will be drawn along the cylinder, leaving a vacuum behind, at a uniform and regular degree of resistance, until the door is released, when the unbalanced pressure of air upon the face of the piston will cause the door to resume its original position. The use of the valve communicating with the outside of the cylinder is that, in case of a leakage of air behind the piston, it shall be driven by the return of the piston through it to the outside. The use of the exhausted chamber and valve communicating with it is, that a portion of the leakage air or oil which cannot be discharged by the valve leading outwards, escapes into the exhausted chamber, which allows the piston to get to the bottom, and to bring the teeth of the rack in hard contact with the teeth of the wheel, and thereby keep the door steady and in its proper place when shut. The box requires to be filled with lard or sperm oil to seal the piston, and keep the whole lubricated.

Description of an Improved Method of Constructing Wire Fences. By Mr. JAMES SMITH.

It was stated that the object of this plan is to increese the simplicity and facility of the construction of wire fences, and to afford easy means of correcting the occasional defects of over tightness or over slackness of the wire lines, whether arising from faults in the construction, or from the vicissitudes of temperature: that this is effected by mounting the straining posts with rollers and ratchet wheels for the wires, by which, with tools of the most simple kind, an ordinary labourer can erect the fence and stretch the wires in the most perfect manner; and the wires, when becoming too slack or too tight, can be easily corrected, so as to keep them always in a perfect state: and that the expense of obtaining these advantages very little exceeds that of constructing the fence on the common method.

NOTES OF THE MONTH.

Important Application of Hydraulic Pressure.—A powerful hydraulic engine has been placed at Murton colliery, belonging to the South Hetton Company, by Messrs. Armstrong and Co., for the purpose of drawing the trains of waggons underground without the aid of a steam-engine (so dangerous in such a situation), or of horses, where a large number would not be so efficient as this new machine. The engine consists of four small cylinders and pistons, each being three inches in diameter, with a 12-in-stroke; the water which supplies the power is that pumped from the shaft, collected in a reservoir 606 feet above the level of the water engine, and, of course, applying an enormous force to the pistons; the pipes conveying the water down the shaft are 4½ inches in diameter; the distance from the shaft from whence the trains are propelled is 880 yards, with gradients from 1 in 30 to 1 in 18; the number of tubs in each train is at present 20 or 21; the time travelling the distance is 4½ to 6 minutes, or 6 miles an hour; the quantity of water pressing on the pistons is 1,500 gallons, and the average speed is 100 strokes per minute, although 130 have been obtained without any jarring motion; the power of the engine is about 30 horses, and the reservoir and column of water collects as much as will draw 20 trains per day; but although it is contemplated to increase that number to 50, that extra number will only involve the pumping of an additional 30 gallons per minute through the 24 hours.

New Brick-Making Machine—.Mr. Hart, engineer, of Seymour-place, Bryanstone-square, is now exhibiting a machine for making bricks, which, besides producing them with greater rapidity than by any previous machine, and at a less cost, possesses the advantage of turning them out in an exceedingly dense and homogeneous form, requiring no great length of time after pressure before they are fit for the kiln. The machine is very powerful, but compact. The clay is placed in a hopper, in a rough state, from whence it passes, in a well-kneaded condition, into the brick moulds, which are placed upon an endless chain; here it passes beneath the presser, which reduces the bricks to the proper size, and after this part of the process they are stacked for drying. It is stated that one horse, two men, and four boys, at a cost of about 1*l.*, can turn out 26,000 perfect bricks, stacked, in 12 hours. The machine is also admirably adapted for pressing into cakes oil dregs, and other similar substances.

ESTABLISHMENT OF A METEOROLOGICAL SOCIETY.—A meeting of gentlemen devoted to astronomical and meteorological pursuits was held at the baronial and hospitable seat of Dr. Lee, of Hartwell, near Aylesbury, last month, which led, during three days discussion, to a good deal of interesting detail on various matters connected with science, and ended in the formation of the British Meteorological Society, to which Mr. Glaisher, the accomplished observer and superintendent of the Meteorological Department at Greenwich, consented to become secretary; S. C. Whitbread, Esq., F.R.A.S., was nominated president; Dr. Lee, LL.D., F.R.S., treasurer; and a Council of several other gentlemen, most of whom are members of the Astronomical Society, was formed. It was arranged that a meeting of the officers should take place on the 7th of May, and that gentlemen desirous of promoting the science might be admitted members on signifying their wishes to Mr. Glaisher, of Blackheath, before that day, after which members will be admitted by ballot. Meteorological Reports are already made from forty different stations in the kingdom, and arranged, condensed, and printed in the Quarterly Report of the Registrar-General, by Mr. Glaisher. It is desirable to increase the number of the stations, and that accurate and regular observations of standard barometers, thermometers, and hygrometers, should be multiplied, with a view to establish some general principles of atmospheric variation, in relation to storms, weather, and diseases. Among the subjects discussed at the meeting was that of meteoric stones, one of which, in the possession of Dr. Lee, had fallen at Launton, Oxon, in 1830, and which had been examined and recorded in 'Loudon's Magazine of Natural History,' by Mr. Stowe, of Buckingham, in March, 1831. Mr. Glaisher had received accounts of the descent of the late meteor from many observers, who estimated its altitude and course, from the Bristol Channel across Wales, and immediately over Northampton, till it burst at the height of 20 miles over Biggleswade, where fragments have been sought for, but at present without success, though its bulk must have been enormous. The interval which occurred between the appearance of the light and the noise of the explosion was measured accurately by the Rev. Joseph Read, of Stone, near Aylesbury, who had a chronometer in his hand at the moment, and was found to be 53 seconds; and another gentleman, 15 miles south of Stone, estimated it at 57 seconds Dr. Lee had sent a model of his Aerolite to the Museum at the India House, and the curator, in return, sent him a model of one that fell in India, which, though of larger dimensions, had very much the shape and character of the Oxfordshire stone, which weighed, at its descent, 2 lbs. 5 oz.

SOUTH WALES RAILWAY.—A wrought-iron bridge of very large dimensions is now in course of construction by the extensive ironfounders, Messrs. Finch and Willey, of Windsor Foundry, Liverpool, who have erected substantial temporary premises for the purpose. The bridge has been designed by Mr. Brunel, the civil engineer of the line, and is to be thrown across the river Wye. Its extreme length will be 600 feet, there being four arches or spans, one of 300 feet, and three of 100 feet each. As the navigation of the river cannot be interfered with, the immense span of 300 feet is rendered necessary, in order to prevent the erection of piers or other works, as a foundation on which to rest the mass of iron-work which will be brought into requisition. The principle adopted is that of suspension from a tube by diagonal chains, which carry the girders on which the line of rails is laid, and besides many other improvements being introduced to adapt the bridge to the peculiarities of the situation in which it will be required. The contraction and expansion of the iron-work is provided for with the greatest exactness; oscillation and undulation from any of those causes by which they are usually produced on railway bridges will be effectually prevented. The roadway will be nearly 150 feet above the level of low-water mark. Large cylindrical pillars are to be driven into the ground near the margin of the river, and from these and the piers, which form the extreme points of suspension, the main support for the structure will be derived. The iron likely to be used in the bridge and cylindrical pillars will amount to 2,000 tons. To expedite the work, a large and very powerful engine has been erected, and extensive machinery brought into working order.

METROPOLITAN COMMISSION OF SEWERS.—An account of the receipt and expenditure of the Metropolitan Commission of Sewers for 1849 has just been published. The receipts amounted to 71,683l. 13s. 10d., the items composing this total being 55,105l. 3s. from rates, 13,518l. 10s. 10d. from contributions, &c., and 3,000l. from loans. The payments were as follow:—For works, 50,309l. 4s. 1d.; surveys. &c., 8,339l. 19s. 10d.; management, 22,400l. 17s. 5d.; loans, 4,014l. 12s. 8d.; contingencies, 250l. 9s. 6d.; making a total of 85,346l. 3s. 6d. The cash in hand at the commencement of the year 1849 was 22,956l. 3s. 7d.; at the end of the year it was 9,234l. 13s 11d. The total amount paid for contracts commenced and completed for general works during the year was 40,606. 5s. 4d., being 10,573l. 11s. 5d. for sewers, 5,577l. 9s. 6d. for openings (side entrances, air shafts, gullies, private drains and flaps), 3,956l. 11s. 5d. for repairs to sewers, gullies, &c., 18,595l. 18s. 10d., for cleansing, including, flushing, casting, and lifting, 1,460l, 2s. 9d. for incidental works, and 452l. 11s. 6d. for paving and gravelling relaid. An additional sum of 2,318l. 14s. 11d. was expended under contracts for special works, being 100l. for incidental works, and 2,218l. 14s. 11d. for sewers. The total amount of monies owing to the Commissioners on account of uncollected rates is 56,171l. 12s. 11d. The debts owing by the Commissioners amount to 100,738l. 1s. 1d., viz. 65,787l. for loans, 465l. 14s. for special contracts, and 34,485l. 7s. 1d. for tradesmen's bills and other obligations not under special contracts.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM MARCH 20, TO APRIL 23, 1850.

Six Months allowed for Enrolment, unless otherwise expressed.

William Joseph Curtis, of Port of Spain, Trinidad, West Indies, civil engineer, for improved machinery and apparatus adapted for the manufacture of sugar.—March 23.

Horatio Carter, of Thirza-place, Old Kent-road, Surrey, gentleman, for certain improvements in the production of light from ordinary coal gas, by the use of burners, consisting of more than one ring or sheet of flame, combined with a suitable chimney or chimneys, and supplied with atmospheric air, particularly adapted to ventilation.—March 23.

Joshua Siddeley, jun., brassfounder, of Liverpool, for certain improvements in ships' fittings.—March 23.

Alfred Wilson, of Myddleton-street, Clerkenwell, clock-case maker, for an improved ventilator.—March 23.

John Stephenson, of Roan mills, Dungannon, Tyrone, flax spinner, for certain improvements in machinery for spinning flax and other substances.—March 23.

William Sykes, of York-street, Middlesex, tallow chandler, for certain improvements in the manufacture of candles and wicks.—March 23.

John Varley and Joseph Hacking, of Bury, Lancaster, engineers, for certain improvements in steam-engines and apparatus connected therewith.—March 23.

Henry Robert Ramsbotham, of Bradford, Yorkshire, manufacturer, and William Brown, of the same place, mechanic, for improvements in preparing and combing wool.—March 23.

John Gedge, of Wellington-street, Strand, Middlesex, for an improvement in lamps and candlesticks. (A communication.)—March 23.

Nathaniel Matthew, of Wern Tremadoc, Carnarvon, quarry proprietor, for an apparatus for cutting or dressing slates into various shapes and sizes.—March 23.

Alfred Guillaume, Rosseleur, of Paris, France, but now of 4, South-street, Finsbury, Middlesex, chemist, for certain improvements in coating or covering metals with tin.—March 23.

Alfred Vincent Newton, of the Office for Patents, 66, Chancery-lane, Middlesex, chanical draughtsman, for improvements in the preparation of materials for the pro tion of a composition or compositions applicable to the manufacture of buttons, kni rasor-handles, ink-stands, door-knobs, and other articles where hardness, strength, durability are required. (A communication.)—March 23.

Edward Welch, of St. John's Wood, London, architect, for improvements in fire-p and flues, and in apparatus connected therewith.—March 23.

Evan Leigh, of Miles Platting, near Manchester, Lancaster, cotton-spinner, for hi vention of certain improvements in machinery or apparatus for preparing and spi cotton and other fibrous substances.—March 26.

Joseph Theodore Clenchard, of Paris, France, manufacturing chemist, for certai dprovements in the application of archil to the process of dyeing and printing in col and also an improved apparatus to be employed in the operation of dyeing.—Marc

James Preece, of Hereford, shoemaker, for certain improvements in mills and chinery applicable to the thrashing and grinding of corn, the manufacture of cider, other similar purposes.—March 26.

Alfred Vincent Newton, of the Office for Patents, 66, Chancery-lane, Middlesex, chanical draughtsman, for improvements in coupling-joints for pipes. (A communicati —March 26.

Thomas Dickson Rotch, of Drumlamford-house, Ayr, North Britain, Esq., for prevements in separating various matters usually found combined in certain sacch saline, and ligneous substances. (A communicatian.)—March 26.

Thomas Walker, of Wednesbury, Stafford, iron-master, for improvements in the ma facture of sheets or plates of iron for certain purposes.—March 28.

James Samuel, of Willoughby-house, Middlesex, civil engineer, for certain impro ments in the construction of railways and steam-engines, and in steam-engine machi —April 5.

Joseph Findlay, of Paisley, Renfrew, North Britain, manufacturer, for an improve or improvements in machinery or apparatus for turning, cutting, shaping, or redu wood or other substances.—April 5.

George Henry Phipps, of Park-road, Stockwell, Surrey, engineer, for improvement propelling vessels.—April 5.

Jonathan Charles Goodall, of Great College-street, Camden Town, Middlesex, c maker, for improvements in machinery for cutting paper.—April 5.

Charles Seeley, of Heighington, Lincoln, merchant, for improvements in grinding wh and other grain.—April 5.

John Platt, of Oldham, Lancaster, engineer, for certain improvements in machinery apparatus for spinning, doubling, and weaving cotton, flax, and other fibrous substa —April 11.

Richard Prosser, of Birmingham, civil engineer, for certain improvements in machin and apparatus for manufacturing metal tubes, which improvements in machinery ar part applicable for other purposes where pressure is required; also for improvement the mode of applying metal tubes in steam boilers, or other vessels requiring metal t applied within them.—April 11.

Amedée Francis Redmond, of Birmingham, for improvements in the manufacture envelopes.—April 15.

Edme Augustus Chameroy, of Paris, for improvements in the manufacture of bo and of pipes of mailable substances, as well as of elastic matter.—April 15.

Robert Reid, of Glasgow, manufacturer, for certain improvements in propellin April 15.

Cuthbert Dinsdale, of Newcastle-upon-Tyne, dentist, for improvements in the ma facture of artificial palates and gums, and in the mode of setting or fixing natural a artificial teeth.—April 15.

John Turner, of Birmingham, engineer, and Joseph Hardwick, of the same place, for certain improvement or certain improvements in the construction and setting of st boilers.—April 15.

George Attwood, of Birmingham, copper roller manufacturer, for a new or improv method of making tubing of copper or alloys of copper.—April 15.

Charles de Bergue, of Arthur-street, London, engineer, for certain improvements in locomotive and other steam engines, also in buffers for railway purposes.—April 18.

John Dove Harris, of Leicester, manufacturer, for improvements in the manufacture of looped fabrics.—April 18.

William Buckwell, of the Artificial Granite Works, Battersea, civil engineer, and George Fisher, of the Taffvall Railway, Cardiff, civil engineer, for improvements in the construction and means of applying carriage and certain other springs.—April 18.

William Henry Ashurst, of the Old Jewry, gentleman, for improvements in the manufacturing of varnishes.—April 18.

Thomas Ross, of Coleman-street, London, gentleman, for improvements in machinery for raising a pile upon woven and felted fabrics.—April 18.

Abraham Moses Marbe, of Birmingham, chemist, for an improved manufacture of vegetable fluid to be used in the production of artificial light, and in lamps or burners for consuming the same; which vegetable fluid is also applicable to the manufacture of lacker or varnish.—April 18.

William Hargreaves the younger of Bradford, York, iron founder, for certain improvements in the means of consuming smoke, parts of which improvements are also applicable to the generating of steam.—April 18.

Peter Arkell, of Chapel-street, Stockwell, Surrey, engineer, for improvements in the manufacture of candle wicks.—April 20.

Alfred George Anderson, of Great Suffolk-street, Southwark, Surrey, soap manufacturer, for improvements in the treatment of a substance produced in soap-making, and its application to useful purposes.—April 20

John Timothy Chapman, of Wapping, Middlesex, for improvmeents in apparatus for setting up ships' rigging and raising weights —April 20.

Richard Archibald Brooman, of the firm of J. C. Robertson and Co., of Fleet-street, London, patent agents, for improvements in the manufacture of zinc, and in the apparatus employed therein.—April 20.

Henry Ritchie, of Brixton, Surrey, for improvements in the manufacture of copper, brass, and other tubes or pipes.—April 23.

William Macalpine, of Spring-vale, Hammersmith, general dresser, and Thomas Macalpine, of the same place, manager, for improvements in machinery for washing cotton, linen, and other fabrics.—April 23.

Charles Humfrey, of Downing College, Cambridge, M.A., for improvements in the manufacture of candles and oils, and in treating fatty and oily matters, and in the application of certain products of fatty and oily matters.—April 23.

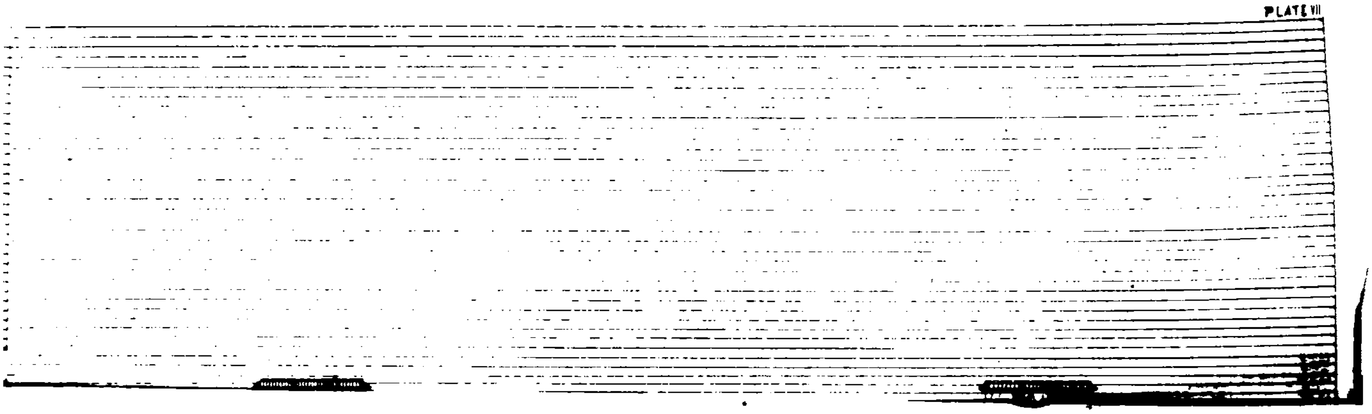
Antoine Pauwels, of Paris, France, merchant, and Vincent Dubochet, also of Paris, France, merchant, for certain improvements in the production of coke, and of gas for illuminating, and also in regulating the circulation of such gas.—April 23.

Richard Laming, of the New Chemical Works, Isle of Dogs, Middlesex, chemist, and Frederick John Evans, of the Horseferry-road, Westminster, gas engineer, for improvements in the manufacture of gas for illumination, and other purposes to which coal gas is applicable, in preparing materials to be employed in such manufacture, and in apparatus for manufacturing and using gas; also improvements in treating certain products resulting from the distillation of coal, parts of which above-mentioned improvements are applicable to other similar purposes.—April 23.

Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in casting type. (A communication.)—April 23.

Pierre Armand Lecomte de Fontainemoreau, of South-street, Finsbury, for certain improvements in the manufacture of wafers, and in the machinery or apparatus connected therewith. (A communication.)—April 23.

PLATE VII



ddlesex, chemist, for certain improvements in coating or covering metals with
rch 23.

BRIDGEWATER HOUSE.

Charles Barry, Esq., R.A., Architect.

(*With an Engraving, Plate* VII.)

ELEVATION OF THE WEST OR GARDEN FRONT.

Little remains to be added to what was said of this work of Mr. Barry's, in No. 156 of our *Journal* (Vol. XII. p. 1), when we gave an elevation of the south front. One thing which we may here do, is to correct an error that may mislead some of our distant readers as to the precise locality of the mansion, the engraver having put "St. James's Park" on the plate instead of the Green Park. That the first-mentioned is not the actual situation is perhaps to be regretted, for where it now stands Bridgewater House is not seen to full advantage, the site being far more favourable as regards the view *from* its windows, than for affording that satisfactory view of it, and that close inspection which so d a piece of architecture is intitled to. Could this palatial residence and Apsley House be made to change places, the ice to Piccadilly would be really imposing, though its imgness would partake also of imposition, by leading strangers ect to find many other noble and aristocratic mansions of a r class, in which we need not say they would be grievously ointed; whereas the insipid, humdrum style, or no-style, of House promises so very little for anything else of similar hat even the *mesquinerie* of Buckingham Palace excites less shment than would else be the case.

two elevations which we have now given of Bridgewater render description superfluous, since it would be only reing what may be far better understood from the engravings. In way of remark, we have merely to call attention to the of detail, and the solicitous finish exemplified in this edifice, hich contrasts so strongly with the carelessness and inequality ign, that detract considerably from the general merit of even of our best buildings. Of the interior of the Earl of Ellese's mansion we are at present unable to speak, but hope that ll be in our power to do so on some other opportunity. The information relative to it we can here give is, that since the e was begun the plan has been considerably altered—in one ect at least—as there will now be a spacious central hall the re height of the building, with colonnades around it, on the l of the principal floor, instead of two small inner courts with first flight of the grand staircase carrried up between them; rding to which arrangement what will now be open colonnades ld have been closed gallery-like corridors, lighted from their ings.

CTURES ON THE HISTORY OF ARCHITECTURE;

By Samuel Clegg, Jun., M.I.C.E., F.G.S.

livered at the College for General Practical Science, Putney, Surrey.

(PRESIDENT, HIS GRACE THE DUKE OF BUCCLEUCH, K.G.)

Lecture VI.

Origin of Greek Architecture.—The Three Orders.

There is no country whose early history is more involved in bscurity and fable than that of Greece. As Josephus remarks, peaking of the Greeks: "As for their care about the writing down of their histories, it is very near the last thing they set about." The Greeks were an ardent and imaginative people, proud of their country, and regarding as barbarians all those who had no claim to the Hellenic name. Their early historians were bards, or rhapsodists, whose recitations, describing the deeds and events that led to the glory of Greece, were listened to with eager interest. Thus, every action and circumstance was painted in the glowing hues of poetry. They disdained an earthly parentage for their heroes, whose descent they traced from nymphs and divinities, and believed that the gods themselves came down from Olympus to take part in their conflicts, or to contest the privilege of presiding over the rising states and cities of their favoured land. The return of the Heraclidæ, and the founding of the kingdom of Lacedæmon, took place about 1104 B.C. Before this, colonies had settled in Ætolia, and the Bœotian Thebes was a flourishing city. In 1044, fresh colonies went out to Ionia; and a band of Greeks had established themselves on the southern shore of Italy, the germ of Magna Græcia. Apollonia, and other cities along the western coast of Greece, were founded by the Corinthians, who carried with them the sacred fire that, if extinguished, might only be rekindled at the holy altar of the mother state. Then followed the foundation of Syracuse, Gela, and other Sicilian cities. Thus, the Hellenic race spread themselves not only over Greece, but in Asia Minor, the south of Italy, and Sicily; shedding over all these countries the light of that genius that seemed their birthright.

A kind of rude Doric and Ionic already existed in Phœnicia, though not formed into those express combinations that could claim the name of "Order." It is probable that the Greeks received their first ideas upon the art of building from that country; but, in the true artistic spirit, they so harmonised and fitted it to their peculiar habits, institutions, climate, and materials, as to have made it so completely their own that it is not worth while to wander in search of its birthplace: it may therefore be accepted, in its early forms as in its fullest development, as *de facto* Greek architecture.

Nature seemed to have combined in that one spot of earth everything that could tend to the advancement of art, that mankind might for once behold perfection. In no age or country has the training of youth so fully called forth the united physical and intellectual powers: the body was strengthened and invigorated by athletic exercises, and the mind enlarged and elevated by the sense of freedom, and a certain responsibility in the state. Equally removed from the severity of the north and the enervating tendencies of the tropics, the frame received elasticity and force, combined with softness and grace. The spirit of rivalry amongst the small states into which Greece was divided, leading to contests of skill in the Olympic and other games, and frequently to struggles of a less peaceful nature, kept their energies awake, and forbade them to sink into the feebleness of repose. The influence of a serene and sunny climate, and a constant familiarity with the grand and beautiful scenes of nature, raised the imaginative faculty to the highest pitch. The Greek saw around him majestic mountains, sinking in picturesque declivities to the cultivated plain below; the island-studded sea, reflecting in its pure depths the azure of the heavens; what wonder that he was haunted by beauty as with a spell, and strove to reproduce in art the ideas of sublimity and loveliness with which he was inspired? Italy, from the same cause, has been the land of painting and of song: but the inexhaustible stores of marble inclosed within her mountains, seemed to denote that nature intended Greece to produce those transcendent works of architecture, and sculpture also, that have been a lesson to all successive ages.

There can be no doubt that construction in wood was the original type of Greek architecture. From such an origin alone could that proper balance of thrust and resistance, that nice adjustment of parts, and accurate knowledge of strength and weight have arisen, that made building first a science and then an art. Though magnificent and gigantic edifices were erected in Egypt, India, and Assyria, it is undoubtedly the fact, that the wooden hut first led to those combinations that produced "The Orders;" and Greece therefore pre-eminently claims our attention as our first mistress in the art, and Greek architecture as the parent of all succeeding styles. Though the wooden hut was the original type, we cannot imagine the log cabin of an indigent peasant to have been the immediate precursor of a splendid stone edifice, fit to adorn a city; nor can the bringing to perfection the wooden model, nor the imitating it in stone, nor the establishment of the orders, be referred to any one individual, or single point of time. No art can be said to be invented, much less one so complicated as architecture: its forms and proportions could only take their rise slowly from the bosom of time and experience. We must suppose that the builders of the first cabin only raised such a structure as would be necessary to shelter them from the inclemency of the weather, and were determined in the form by the nature of the materials at hand. The arid plains of the south and east were left behind with their scanty growth of palm and poplar; and dense forests were spread on all sides, offering a new and plentiful material to the ingenuity of the first settlers. They therefore hewed trees, and placed their trunks upright in the ground to support the roof, filling-in the intervals with intertwining branches made weather-proof with turf or mud; other trunks would then be laid horizontally upon the uprights, and covered over with boughs and rushes, or turf—and the primitive hut would be completed. As the damp penetrated to their dwellings, they would find the necessity of laying a flooring of timber, and raising the roof by rafters meeting at an angle to throw off the wet. A hut so constructed would suffice for all the material wants of its occupants. But as man becomes civilised, the love of the beautiful arises—his eye requires to be pleased, as well as his mere physical necessities provided for; and from this faculty of our nature the fine arts result. First, the bark would be stripped from the tree, and the trunks that were to serve as uprights, rounded smooth. The beams would be squared, and a more efficient support given to them by square slabs placed upon the pillars. Amongst a rich and agricultural people, other improvements would gradually take place; and decoration would follow, until the wooden structure was perfected, with its stylobate, columns, entablature, and pediment, adjusted to the nicest proportions that experience and taste could dictate. The poems of Homer inform us that the first temple at Delphi was of wood; and it is supposed that the old Temple of Neptune at Mantinea was constructed of the same material. After a time, as wealth and luxury increased, and more elaborate edifices were required, brick and stone began to replace the primitive materials; but, at first, only partially. We have seen that in the Etruscan temple, both stone and wood were used; and it is highly probable that this was the case, also, in the older Greek temples, as we read of so many being destroyed by fire. The second temple at Delphi, built by Agamedes and Trophonius, the Hecatompedon at Athens, and several others, shared this fate; a catastrophe which could scarcely have happened had they been, like the Parthenon, entirely of marble. Remains of construction in brick are also met with; though these, in a country abounding in stone, like Greece, are rare. The walls of Mantinea are of crude brick. At Argos are vestiges of a temple of terra-cotta; and another example existed in a portico at Epidaurus. Even in building in wood, certain maxims must have impressed themselves on the minds of the first architects, such as that the heavy should support the light, and the strong the feeble; that solidity should not only be real, but apparent; that nothing should be introduced, even in the way of ornament, without its seeming to arise from some necessity in the construction, as nothing can be beautiful that is not appropriate; and that all the parts and details should be subordinate to the whole. In course of time, as buildings for different purposes were required, three orders, or distinct combinations, were formed, each differing from the others, and taking their rise from different ideas. The Doric, expressive of grandeur, strength, and solidity; the Ionic, of dignity combined with elegance and grace; and the Corinthian, of lightness and festive sumptuousness: and these ideas, notwithstanding the infinite modifications of which the orders are susceptible, were always kept distinct. As the original type of the wooden structure is more closely adhered to in the Doric than in the other orders, it has been generally considered as the earliest; though there is no foundation for such a supposition. According to Vitruvius, the Doric order was invented by Dorus, the son of Helen and the nymph Optieus, who governed the whole of the Peloponnesus, and dedicated a temple to Juno, in the city of Argos; and that this order of architecture was adopted by the cities of Achaia, and from its inventor received the name of Doric. But such a fabulous origin proves nothing beyond its antiquity; nor is a name any better guide—for instance, no vestige of the order called Corinthian is found in Corinth, nor does the acanthus grow plentifully in its neighbourhood. A name is often given to a style long after its introduction, and arises sometimes from the country where it was most generally in use, sometimes from some artist by whom it was embellished, or other fortuitous circumstance.

The principal features of the Doric order are, the massive column springing direct from the stylobate, without base, and tapering considerably towards the capital; the bold ovolo, or echinus, and projecting abacus with which the column is crowned; the solid architrave, and enriched frieze, calling to mind the primitive forms from which it took its rise; and the cornice composed of few but varied lines,—altogether forming a combination of unequalled simplicity and grandeur.

Vitruvius tells us that the first architects, in the absence of fixed proportions, bethought themselves of measuring the human figure; and, finding the length of the foot one-sixth the height of a full-grown man, they adopted this as the proportion, making the column six diameters high. This rule, however, is proved to be fallacious, by actual admeasurement of the Greek Doric, in the best examples of which the columns are not as much as six diameters in height. Moreover, architecture does not imitate nature, but proceeds on the same principles as nature herself. In an organic structure there are certain proportions which are never overstepped—certain adaptations of parts to a whole, which are always preserved; though, within these limits, there is perfect freedom. Thus in a skeleton, if we see one bone, we can at once decide to what species it belongs; and yet the individuals of that species are so infinitely varied that no two are exactly alike. Thus worked the architects of Greece, in the secondary forms and proportions, adhering to no positive rule, but varying them according to the dictates of taste and judgment. Nor should this excite our surprise; rules never produced a work of genius; they are the result —the effect, not the cause of such works. A great artist arises; his productions transcend all that has gone before, and at once command the suffrage of the public: they become an example—a rule. But let the student beware of imagining that, by exactly following such rules, he will achieve like results. As well might a painter take a *chef d'œuvre* of Raffaelle's, and say, by following such and such lines, and imitating such and such masses of light and shade, and combinations of colour, I shall produce a picture like this; or a musician fancy he could compose a symphony like one of Beethoven's by studying thorough base. The most that could result from such a course of study would be a cold correctness, that might not offend, but would utterly fail in commanding admiration. It was a saying of Michael Angelo's, "that the man who follows another is always behind; but he who boldly strikes into a different path, may climb as high as his competitor." Rules are valuable to repress exaggeration and extravagance—they serve to mark the limits beyond which grandeur and energy would be lost in clumsiness, or elegance and grace degenerate into poverty and weakness; but within these extremes the imagination may stray at will. Those who would make architecture nothing but a system of rules, would render it no longer an art, but a mere mechanical trade.

In architecture, the constituent parts of every structure, however vast and complicated, are composed of a few elementary forms; thus, the buildings of the Greeks may be divided into four principal parts —the platform, or stylobate; the columns, serving as supports; the entablature, connecting and resting upon these; and the pediment and roof, crowning the whole. The character of the order is not confined to one part, but is spread over all; but the column is the indicator and regulator: thus the names of the different orders are given to the supports, according to their style. Hence they are called Doric, Ionic, or Corinthian columns. It is impossible to assign any chronological order to the ancient edifices of Greece. Generally speaking, in the earlier examples, the column is more massive, with fewer flutings, and supporting a heavier entablature; but this is by no means an infallible rule. Nor can we trace the rise of Greek architecture from progress to progress, as in other styles, for the temples of the remotest antiquity are as beautiful and complete as those of a later date. The hypæthral Temple of Pæstum is scarcely, if at all, inferior to the Parthenon itself. Indeed, Signor Lusieri (a great authority in matters of taste) considered the Temple of Pæstum as an example of a more correct and pure style; and thought that the Doric order there attained an excellence beyond which it never passed. He observed, "Not a stone has been placed there without some evident and important design; every part of the structure bespeaks its own essential utility." His opinion was the same with respect to the ancient Temple of Jupiter Panhellenius, in Ægina: "Of such a nature," said he, "were works in architecture, when the whole aim of the architect was to unite grandeur with utility, the former being founded on the latter: all then was truth, strength and sublimity." It was not until the year 1745 that attention was drawn to the ruins of Pæstum. Though in the year 1675, Athens was visited by the Marquis de Nointel, Dr. Spon, Sir George Wheler, and Mr. Vernon, who all published the result of their researches, the architects of that day knew so little of the pure Greek Doric, that the temples at Pæstum were for some years considered as unique; and in France this style was called the order of Pæstum, and it was not until Messrs. Stuart and Revett went to Athens in 1751, that the beautiful remains of Greek architecture were made known to the public.

When the ruins of Pæstum were first examined, in the total absence of history or inscriptions, many speculations were afloat respecting their origin. Signor Paoli imagined them to be Etruscan, because Pæstum, then called Phistu, was in existence before the Greek orders were known, Jason having offered libations there; but the Chevalier Boni very truly remarks, that such a tradition "only proves the antiquity of the place itself, not of everything it contains." Pæstum was one of the earliest Greek settlements in Italy; and by them called Poseidonia. Mr. Wilkins, speaking of the hypæthral temple (supposed to have been dedicated to the tutelary deity of the city, Poseidon, or Neptune), says, "The Grecian character is too strongly marked to admit of any argument, and must have been coëval with the very earliest period of the Grecian migration to the south of Italy. Low columns, with a great diminution of the shaft, bold projecting capitals, a massive entablature, and triglyphs placed at the angles of the zophorus, are strong presumptive proofs of its antiquity." The pseudo-dipteral temple does not belong to a period of such correct taste; indeed, it has been supposed to be of Roman rather than Greek workmanship. The columns have a peculiar capital—a row of small leaves encircle the neck, and turn over, as if supporting the lower fillet. These temples are built of a kind of stalactite, of the same nature as the travertine, formed by a calcareous deposit. The Temple of Ægesta, or Segesta, in Sicily, is another ancient example of the Doric; it is, I believe, the only instance in which the columns were unfluted. In several ruins, the columns would appear at first sight to be plain; but the Greeks did not work the flutings till after the column was raised, the channels under the capital, and at the base, being previously marked to serve as a guide to the workmen. In some instances the columns were left unfinished; though the above-mentioned marks may still be detected. In the ruins of the Temple of Apollo Didymæus, near Miletus, there are two fluted columns yet standing, and one plain; but with the channels marked above and below. There is a wide interval of time between the building of the hypæthral temple at Pæstum, and that of Jupiter at Agrigentum, which was left unfinished at the time of the destruction of the city by the Carthaginians, 405 B.C. Nevertheless, no great difference is apparent in the style, only that diversity of proportion and detail which is always seen in Greek architecture. It was said of the Agrigentines, that they pursued pleasure as if they had only a day to live; and built as if they were never to die. The gigantic proportions of the Temple of Jupiter brings this saying to mind, the lower diameter of the columns being 12 ft. 11·7 in., and their height 63 ft. 4·6 in. According to Diodorus, a man could stand in each fluting. There were three other considerable temples at Agrigentum, and several at Selinunte, another ancient Greek town in Sicily. All these temples were of the Doric order, and yet not two precisely similar; showing that the same design was never repeated even in one city. In the Temple of Neptune at Pæstum, the columns are only four diameters in height; those of the old temple at Corinth bear the same proportion. The columns of the Temple of Theseus in Athens, were rather more than 5 diameters high; of the Parthenon, nearly 5½; of Jupiter at Agrigentum, 5 diameters; in the Temple of Apollo Epicurius at Bassæ, the columns are rather more than 5½ diameters high; and as we approach a later and less correct age, the proportions are still more slender. In the Portico of Philip at Delos, the columns are 6½ diameters in height.

It does not appear that the entasis was used in the more ancient examples; indeed, it would naturally be one of the last refinements of art. The columns of the Temple of Neptune at Pæstum, have been proved to be without entasis, though not always so represented. Pæstum, since its desertion, has become a perfect marsh; and the damp eating away the stone at the lower part of the column, has given them the effect of swelling in the middle. The column, in the ancient Doric, appearing to diminish too rapidly, would cause some architects to endeavour to remedy this defect. This was done by slightly increasing the diameter towards the middle of the column, though always keeping it within the lower diameter. This swelling out, called by the Greeks "entasis," should not be visible, being only intended to give the effect of a gradual diminution. Mr. Cockerell was the first to discover the entasis in the columns of the Parthenon. In a degenerate age, this refinement was exaggerated, as in the pseudo-dipteral temple at Pæstum; and thus became a defect instead of an additional beauty.

The number and manner of the flutings in the Doric shaft varied considerably. There is a ruin of a Temple of Apollo Thearius at Trœzen, in Argolis, the columns of which have eight plain sides. In the Portico of Philip at Delos, the upper part of the shaft is fluted; while the faces are plain towards the lower diameter. In a Doric temple at Orchomenus, in Arcadia, the columns have 18 flutings; in the ancient temple at Corinth, 20; and in the Temple of Neptune, Pæstum, 24. The flutings in this order are shallow and meet at an edge, without intervening fillet.

The custom of fluting the shaft has never been satisfactorily traced to an origin, some supposing it to have arisen from the grooves formed in wooden pillars by the water trickling down; other from the stalks of plants; and others, again, from observing the fluted shell common on the coast of Greece. Probably, the columns were in the first instance polygonal, the channelling being a subsequent improvement.

The simple abacus of the Doric order is a representation of the primitive square block, placed on the pillar for the better security of the beam. The echinus or ovolo would result from bevelling off the abacus to meet the shaft; such a capital was found in an Etruscan tomb at Bomazzo. The ovolo afterwards became a separate member, and was quirked under the abacus, and moulded into a more elegant form, by increasing taste.

The profile of the Doric capital varies in each building, the form of the ovolo depending upon its depth and the projection of the abacus, the general proportion of the latter being to the lower diameter, as 1·25 to 1. The ovolo is united to the hypotrachelium, or neck, by several fillets, varying in number from three to five. In some examples they are omitted; but these are rare. The same variety is seen in the number of annulets encircling the neck of the shaft. In the Temple of Neptune there are three; in the Parthenon one; and in other instances the flutings are continued up to the fillets, without interruption. The intercolumniations in the Doric order are narrow, adding to the general character of grandeur and solidity. One diameter is the general proportion, but in some examples they are 1⅓; and in an ancient temple in Sicily, less than one diameter.

The Doric entablature is massive and simple, and divided into few parts, the proportion being nearly two diameters in height. The architrave or epistylium is plain, with the exception of the guttæ.

In most of the Greek buildings, the architrave, instead of being even with the upper diameter of the shaft, projects so as to be nearly on a line with the lower diameter; but to prevent this superincumbent weight from crushing the projecting part of the abacus, there is a slight space left at the outer edge, which throws the weight on the centre of the capital, and at the same time gives greater distinctness of outline. The frieze is the only part enriched, though the decoration strictly recalls the primitive type. The word "frieze" is derived from the Italian *fregio*, ornament, which is taken from the Latin *phrygius*, embroidery. The Greeks and Romans gave this member the name of zophorus, or figure-bearing. The triglyphs represent the ends of the joists resting upon the beam. It was the custom, anciently, to lay these joists upon the tie-beam, of such a length as to project considerably beyond the external face of the wall, as may be seen in the Etruscan temples. In later times, to improve the appearance, the ends were cut away even with the beams. It is supposed that the three glyphs or grooves are traditional, and that such notches were cut in the ends of the joists to allow the water to run off; the drops hanging below being represented by the guttæ. Others think the triglyph was originally a mere ornament: to conceal the ends of the joists in wooden buildings, we are told the ancients used to cover them with blue wax, by way of decoration. In some examples the triglyphs are not carved on the block of the frieze, but on a separate slab of stone fastened on. The Greeks always placed triglyphs at the angles of the frieze; this was probably done, to present the subjects carved on the metopæ in an uninterrupted series.

To obviate the difficulty of the end metope being thrown out of proportion, the end triglyphs were slightly enlarged, or the intercolumniation at the angle narrowed; an example of this last method is seen the Temple of Theseus at Athens.

The guttæ were either rectangular or conical; or, as is universally the case in Sicily, cylindrical. They were always six in number. In ancient times the metopæ were open spaces between the triglyphs. This is mentioned in a passage of Euripides, where Orestes and Pylades are concerting a plan for carrying off the image from the Temple of Diana. Pylades recommends his friend to creep through the opening between the triglyphs, and so gain access to the interior of the temple. The spaces were afterwards filled-in with slabs; and lastly, the metopæ were enriched with bas-reliefs, the subject being always appropriate to the service of the temple.

The cornice of the Doric order is bold and simple: its characteristic is the mutule, representing the ends of the rafters composing the roof. The mutule was decorated with three rows of guttæ, six in each row. The mutules were never repeated along the cornice of the pediment, as in some modern examples: the Greeks had too much taste to represent in sculpture what could not have existed in reality.

In the Temple of Neptune at Pæstum, and that of Jupiter Panhellenius in Ægina, the upper member of the cornice is a cavetto. In many other temples it is an ovolo. The cyma was not an integral portion of the early Doric; indeed, it is not supposed to have become an established part of the order until after the age of Alexander the Great; where the cyma is introduced, as in the Temple of Apollo Epicurius, it is generally enriched. The Doric pediment was slightly less elevated than in the other orders, giving it a graver character; the tympanum was sufficiently deep to allow of statues being placed within. Thus every part of the Doric order was calculated to impress the idea of strength, sublimity, and energy; not only by the massiveness of its proportions and the simplicity of its details, but by the boldness of relief given to all its mouldings and ornaments—adding, by deep masses of light and shade, to force and grandeur of outline.

It is quite as impossible to trace the history of the Ionic as of the Doric order; but we have no reason to suppose it of a less ancient date. As before mentioned, Vitruvius informs us that the proportions of the human figure were adopted, the Doric representing the manly stature, and being employed in erecting temples to the gods. But, he adds, the Ionians now wished to dedicate a temple to Diana, and sought to invent a new order in her honour. This they did by giving the column the proportion of the female figure, that it might be emblematical of feminine delicacy; so the columns were made eight diameters high, and had bases given to them in imitation of sandals. The volutes represented the ringlets on either side the face, and the flutings the folds of the garment falling to the feet; they thus presented the likeness of a woman richly adorned. This account is evidently more fanciful than correct.

Other authors think the Ionic order may have been borrowed from India or Persia; and other more imaginative writers have fancied a resemblance to the volute in the curling bark of the first rude wooden pillar.

The idea of the volutes being imitated from the horns of goats or rams appears much the most probable. Altars were erected to the gods long before temples were thought of. These altars were usually decorated with, and sometimes wholly composed of, the skulls and horns of the animals slain in sacrifice; and as far back as history leads us, the ancients built their altars with horns at the corners. "The horns of the altar" is an expression frequently met with in the sacred writings; thus, in Exodus xxxviii. 1, 2. "And he made the altar of burnt offering of shittim wood;" "and he made the horns thereof on the four corners of it:" and in the 1st Kings, ii. 28: "And Joab fled into the tabernacle of the Lord, and caught hold on the horns of the altar." The use of these horns is explained in Psalms, cxviii. 27, where the psalmist exclaims, "Bind the sacrifice with cords, even unto the horns of the altar." When temples were erected, these horns might very probably have been represented as ornaments on the capitals of the columns.

Hermogenes of Alabanda, and his colleagues, who were employed in the restoration of the temples of Asia Minor after the Persian invasion, brought the Ionic order to great perfection. They maintained that the Doric was unfit for temples; and from this time the Ionic order prevailed as exclusively in Asia Minor as the Doric in Magna Græcia. In the latter country the Doric may have become sacred from association, recalling the mode of construction of the mother country; but in Asia Minor, where the wooden dwellings were still in use, and where they have continued even to the present day (the huts of the peasantry still showing the primitive type), this order may have become too familiar to be associated with the service of the temple; and the volutes having a religious origin, the Ionic would consequently be preferred.

Though the Ionic always retains its distinctive characteristics, it varies in detail quite as much as the Doric. In this order, expressive of grace and elegance, the parts are multiplied—a base is given to the column; the shaft is made more slender; the diminution from base to capital less; the number of flutings is increased (the best examples having twenty-four), they are also divided by a fillet, and channelled to a greater depth; the architrave is composed of three bands or fasciæ; the ornaments on the frieze, recalling the wooden structure, are suppressed; the denticulus replaces the Doric mutule; and each member and moulding is made more delicate in outline, as well as more elaborate in decoration. The Ionic does not appear at first to have been so distinct an order: several instances exist, especially in Sicily, of Ionic columns with a Doric frieze; these are supposed to be very ancient. The earliest mention of the Ionic order, is met with in Pausanias, where he describes the Treasury at Olympia, erected by Myron the Tyrant of Sicyon, about 650 B.C., as having two chambers, one Doric, the other Ionic. Next follow the Temple of Diana at Ephesus, and the Heraion or Temple of Juno at Samos: of the first, we have nothing left but vague description: Herodotus mentions the latter as being one of the most stupendous edifices built by the Greeks, and was completed about 540 B.C.

The small Ionic Temple on the Ilissus is one of the most ancient, the ruins of which still exist; the columns are only eight diameters in height, the upper torus of the base is fluted, and like that of Juno at Samos, the lower torus rests upon the stylobate without intervening plinth. The capital is simple but elegant, the lower band has a graceful curve between the volutes, and the channels have a double border. The entablature is two diameters in height; the arhitrave is plain without the usual fasciæ; the denticulus is also omitted. The frieze is supposed to have been originally decorated with bas-reliefs.

We learn from Pausanias, that on the opposite side of the Ilissus stood an Ionic temple dedicated to Eucleia, or illustrious Fame. On the very spot described, a singular Ionic capital has been found built into the wall of a modern edifice: no doubt this capital belonged to the "naos of Eucleia." The upper diameter of the shaft is 1 ft. 1·65 in.; a star-like flower occupies the centre of each volute: the lower band instead of forming a continuous curve between the volutes, turns up again, each side terminating in a flower and two tendrails. Another flower is carved in the centre of the capital. As far as we know it is unique, and probably of very early date.

In the celebrated Temple of Bacchus at Teos, built by Hermogenes, the columns are 8½ diameters high, and of the two porticoes of the Erechtheion, those of the northern or Minerva Polias are 9, and those of the eastern portico 9½ diameters in height. In another often-cited example, the Temple of Minerva Polias, at Priene, not one column remains entire; it is therefore impossible to ascertain the exact elevation.

The bases and capitals vary in each example. In the Temple of Bacchus, the Athenian base is seen; in that of Minerva at Priene, the Ionian: both these are proper to the order. The Athenian consists of two tori, with a scotia between, separated by small fillets. The Ionian of two scotiæ, with two astragals both above and below, as well as between them; over all is a large overhanging torus. This produces the unpleasant effect of being weak, and liable to snap below the heavy torus.

According to Pliny, the Ionian base was first introduced in the Temple of Minerva at Priene, and as this temple was completed and dedicated by Alexander the Great, it belongs to a period when Greek art had already begun to decline, when a minute attention to detail had taken the place of general boldness of design. In the capitals of the Temple of Bacchus the channel connecting the two volutes has no border on the lower edge, but terminates in a horizontal line tangent to the commencement of the second revolution of each volute. The Ionic order is found in its most elaborate and beautiful form in the double temple called the Erechtheion at Athens; but as this building will be described at length in another place, it is not necessary to give it further mention here.

In the Greek Ionic, the volutes present a flat face on the two opposite sides of the capital, the flanks or balusters being generally formed like two cones, united in the centre by an ornamented band or fillet. In the angular columns the volutes are contrived to present the same face in flank as in front, and the returns are likewise placed at right angles instead of on opposite sides.

The third and most sumptuous order, the Corinthian, is more slender in its proportions than either the Doric or Ionic, "with an intention," according to Vitruvius, "to make the form of the column accord with the more delicate proportions of the maiden figure." The invention of this order has been given to Callimachus, and the following pretty story is related by Vitruvius, as giving rise to the idea:—A Corinthian virgin, who was of marriageable age, fell a victim to a violent disorder; after her interment, her nurse, collecting in a basket those articles to which she had shown a partiality when alive, carried them to her tomb, and placed a tile in the basket for the longer preservation of its contents. The basket was accidentally placed on the root of an acanthus plant, which, pressed by the weight, shot forth towards spring its stems and large foliage, and in the course of its growth reached the angles of the tile, and thus formed the volutes at the extremities. Callimachus, happening at this time to pass by the tomb, observed the basket and the delicacy of the foliage which surrounded it. Pleased with the form and novelty of the combination he took the hint for inventing these columns, using them in the country about Corinth."

The merit to which Callimachus can really lay claim is to have fixed and determined the proportions of the Corinthian order more accurately than it had been done before. The distinguishing feature of this order is the bell-shaped capital, ornamented with foliage, a form repeated in endless diversity amongst the Egyptians more than 1000 years before the time of Callimachus; and Josephus tells us that the roof of the Hall of Justice in Solomon's Palace was supported by pillars of the Corinthian order. The bell-shaped capital from its height, and its capability of being highly ornamented, is particularly suitable to an order intended to surpass all others in richness and lightness of effect, and the difference between the Egyptian lotus flower capital and the Greek Corinthian, is no more than would result from its adaptation by a people of taste and genius.

The following proportions are laid down by Vitruvius for the Corinthian capital:—"The height including the abacus is equal to the lower diameter of the columns, and the diagonal line, drawn from the opposite angles of the abacus, is twice the height of the capital. All the fronts of the abacus are of equal extent, and are made concave, the central point in each front receding $\frac{1}{9}$th part of the extent comprehended between the angles. The diameter of the capital at its base is the same as that of the columns below the astragal and apothesis. The depth of the abacus is $\frac{1}{7}$th part of the whole height of the capital, the remainder is equally divided into three parts, one of which is occupied by the lower leaf, the second is given to the middle leaf, and an equal space remains for the cauliculi, whence those leaves shoot which projecting forwards appear to support the volutes. The volutes spring from the leaves of the cauliculi, and extend to the angles of the abacus: the lesser helices are carved in the middle of the capital below the flowers in the abacus, and are made as large as the height of it will admit."

How little these rules are applicable to the generality of Greek Corinthian capitals may be seen by referring to the two most perfect examples now remaining—the capital of the Choragic monument of Lysicrates, and that of the Tower of the Winds, both in Athens.* If the rule always held good that the simple precedes the elaborate, we should ascribe to the latter the earliest date; but that is not the fact. The most ancient known example of Greek Corinthian is a column in the interior of the Temple of Apollo Didymæus, built by Pæonius, 479 B.C. The Choragic monument of Lysicrates was not erected till the year 355 B.C. In this capital the lowest row consists of plain water leaves; then follows a row of acanthus, with flowers between the leaves; above these are the cauliculi with large bold volutes, supporting the abacus. One great singularity in these columns is that the flutings of the shafts terminate above in leaves. It has been supposed that the vacancy left between the shafts and the capital was originally occupied by a metal astragal. The Tower of the Winds at Athens, dates 159 B.C., but the beautiful curve of the bending water leaves, and the exquisite forms of the acanthus, mark this capital as a work of pure Greek art. A similar capital was found among the ruins of the Bœotian Thebes, and another in the island of Milo has two rows of acanthus below the water leaves.

The Temple of Jupiter Olympius at Athens is generally cited as an example of the Greek Corinthian in its most perfect form, differing but slightly from the rules of Vitruvius; but it is doubtful whether either this temple, or that of Jackly, near Mylasa, can be said to be purely Greek. The Greeks never applied the Corinthian order to the exterior of sacred buildings, but confined it strictly to structures of a light and ornamental character, and to interior decoration. There are instances where the Ionic order has been employed in the interior of Doric temples, of one Corinthian column being placed at the end of the cella, as if to continue the gradation: this was the case in the Temple of Apollo Didymæus, and in that of Apollo Epicurius at Bassæ.

Though the Temple of Jupiter Olympius was originally commenced by Pisistratus, and for a time continued by his sons, it was left a mere foundation until the time of Antiochus Epiphanes, 400 years afterwards. We have no proof that it was originally intended by Pisistratus to be of the Corinthian order, nor is it likely that he should in that age have so far violated the feelings and customs of the Greeks, as to have dedicated that light and festive order to the supreme divinity; besides, Pisistratus died in the year 527 B.C., and Callimachus, who at any rate is allowed to have perfected the Corinthian, and given it those proportions so justly admired, lived at the end of the Peloponnesian war, which terminated 404 B.C.: so that it is difficult to believe that the capitals of these columns were designed more than a century previous to its existence, particularly when we compare them with those of the Choragic monument. When Antiochus Epiphanes undertook the construction of this magnificent edifice, he employed a Roman of the name of Cossutius, the first Italian architect on record: it was still however left unfinished, and was partly destroyed by Scylla, and at last restored and completed by the Emperor Hadrian, 700 years after its first foundation.

The Temple at Jackly is open to the same objection, being also of the time of Roman domination, when Roman taste had already begun to prevail over the pure and severe style of the Greeks. The Corinthian order is susceptible of great diversity—the shaft may either be plain or fluted; the Attic base is usually employed. The upper torus is sometimes doubled, as in several examples in Asia Minor; the tori are generally enriched with the guilloche or other ornament. The Corinthian entablature has nearly the same proportions as the Ionic, and, like this order, the frieze may either be plain or elaborately adorned. The distinguishing feature of the Corinthian cornice is the modillion; but from the before-mentioned scarcity of examples of this order in Greece, it will be described more at length in treating of the architecture of Rome.

I have now endeavoured to sketch the portraits of the "Three Orders," as they were practised in Greece; in my next lecture I propose to take a survey of Athens, as a type of an ancient Greek city, and as the principal school of art. I shall then proceed to describe the temples, theatres, and other principal edifices of Greece, showing the manner in which the orders were applied.

LIST OF AUTHORITIES.

Vitruvius.—Antiquities of Athens, Stuart and Revett.—Antiquities of Ionia, Dilettanti Society.—Antiquities of Magna Græcia, Wilkins.—An Inquiry into the Principles of Beauty, Lord Aberdeen.—Encyclopædia Methodique, G. de Quincy.—Architettura Antica, Canina.—Tour in Greece, Dr. Wordsworth.—Travels in Greece, Clarke,—Travels in Greece, Chandler.—History of Greece, Grote.

REPORT OF THE COMMISSIONERS APPOINTED TO INQUIRE INTO THE APPLICATION OF IRON TO RAILWAY STRUCTURES.

(Continued from page 116.)

We owe some apology to our readers for delay in noticing the admirable series of experiments instituted by the "Iron Commission," to illustrate the effects of loads travelling along girders. The experiments may be divided into two classes—those performed at Portsmouth by Captain James and Lieutenant Galton, and those performed subsequently and independently by Professor Willis at Cambridge.

In both sets of experiments the principal characteristics were the rapid transit of loaded carriages over horizontal bars, and the method of producing the velocity of transit by causing the carriages previously to descend an inclined plane by the accelerating force of gravity. The loaded carriages ran on a railway on the inclined plane, and the oblique descending motion was converted gradually into a horizontal one by connecting the inclined and horizontal portions of the railway by curved rails, which avoided the abruptness of transition from one straight line of rail to another.

The motion of the carriage, then, previously to its reaching the beam to be deflected, is horizontal, and therefore comes on the beam under circumstances precisely analogous to those under which a railway train in practice passes over a bridge. And yet the absurd speculations which have been hazarded on this point! We have heard—but sincerely trust that our information is incorrect—of quasi-philosophers undertaking to gravely, even publicly, criticise the method of experiment on this ground—that previously to coming on the beam the experimental carriage had acquired, by its motion on the incline, a *downward tendency or momentum, which might have been the real cause of the increase of deflection of the girder!!*

There is something almost ludicrous, if it were not very pitiable, in the fact that Professor Willis has had to defend himself against such cavillers as these—men, too, possessing some name and authority. What can be said to clear up such a hopeless confusion of ideas? It would be idle to answer, that after the motion of the carriage has become horizontal, it is perfectly unaffected by any motion which it had a minute or a twelvemonth previously. We had, on commencing this paper, some idea of endeavouring to argue the point seriously, but further reflection shows the hopelessness of the attempt. All that can be done is to lament the prevalent ignorance of sound dynamical principles which such a

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* See Stuart and Revett.

melancholy exhibition indicates. Engineers incur most serious responsibilities in providing for the security of railway travelling, which are faithfully discharged by those only who possess sound and scientific knowledge of mechanics—not by those who content themselves with the inaccurate undigested notions which they call *practical knowledge.* Until such discussions as that above referred to, have ceased, there will be always a well-grounded apprehension that the assumption of scientific rank is a mere cloak of quackery, empiricism, and presumptuous incompetence.

Of the two series of experiments upon the dynamical deflection of girders, those conducted at Cambridge by Professor Willis must be considered the most effectual for the discovery of the mechanical laws of this subject. It is not always the most *direct* experiments which are the most conclusive. Indeed, the great art of experimenting consists in abstracting various incidental causes which have no real bearing on the question at issue, but tend merely to complicate the results from which laws are to be inferred.

Of course this abstraction of incidental circumstances, which are of real occurrence in practice, must be made cautiously and on scientific principles. Unless it be conclusively shown that the causes abstracted are immaterial, an essential link is wanting in the chain of argument deduced from the experimental results.

In the experiments at Portsmouth the carriage travelled over two trial bars at once; in the Cambridge experiments over only one bar at a time. In the former series, the load during its transit always pressed on two points of each bar at once; in the latter series only on one point. Now, the simultaneous employment of two bars introduces this difficulty—that, because it is impossible to have both exactly of the same rigidity, one will be deflected in a different way to the other; consequently there will be, during the transit, a rocking or lateral oscillation of the carriage, which unduly affects the observed deflections. Again, if two wheels of a four-wheeled carriage press at once on one bar—the bar being 9 feet long, and the axles of the wheels nearly 3 feet apart—there is an inevitable complexity. For at the commencement of the experiment only the fore wheels, at the end of the experiment only the hind wheels, press on the bars—part of the load being at those times borne by the permanent railway beyond the bars: also the theoretical computation of the curves of deflection, on the supposition of a simultaneous pressure on two points of the trial, would be of the most embarrassing nature. Consequently, it would be all but hopeless to attempt an exact comparison between the results of the Portsmouth experiments and the corresponding results of theory.

Nevertheless, the series of experiments carried on by Captain James and Lieutenant Galton were very valuable in themselves—for they exhibited distinctly the effect of the inertia of the beam in resisting its dynamical deflection. It was shown in the number of this *Journal* for September 1848, in the paper on *The Dynamical Deflection and Strain of Railway Girders*, by Mr. Homersham Cox, that when the inertia of the load and bridge respectively bear anything like the proportions observed in practice, the increase of deflection due to the ordinary velocities of the load is inconsiderable. But in the experiments at Portsmouth the dynamical deflections greatly exceeded the statical. The results were, indeed, of a nature to surprise those who had not maturely considered the whole question; but this apparent contradiction of the daily experience of railway travelling ceased when it was reflected that the trial bars were purposely made very light, so that their deflections might be large and easily observed. The relation between the sustaining and moving masses entirely differed from practical proportions; and the beam possessed so little resistance of inertia (to adopt loose phraseology) as to be susceptible, in an excessive degree, of dynamical influence.

In the experiments conducted by Professor Willis, several refinements were introduced, and a beautiful mechanical contrivance was employed by him, which showed, with great precision, the effects of inertia, and explained "the great and startling increments of the deflection" above referred to. The contrivance in question was termed by the Professor the *Inertial Balance.*

The mechanism of the Inertial Balance consisted of a loaded lever, carefully poised at its centre of gravity on a fixed fulcrum, and connected by other multiplying levers with the centre of the trial bar; so that for a slight deflection of the bar the loaded lever must necessarily turn through a considerable angle. Now, it is apparent that by this contrivance the inertia of the beam was increased, but not its elastic strength. For as the balance was poised, it could have no statical effect, except that due to friction of pivots; and accepting the friction as inconsiderable, a weight at rest on the trial bar would produce the same deflection whether the balance were applied or not. But though the statical strength of the trial bar remained unaffected, its dynamical strength might be increased *ad libitum;* the moment of inertia of the loaded balance was easily comparable by known theorems of mechanics, with the effect of the simple addition of increased mass at the centre of the bar—such mass acting by its inertia only, and not by its gravity.

The balance was provided with two shifting "bobs," of equal weight, which, as they were always placed at equal distances from the fulcrum, counteracted each other's weight, but increased at pleasure the moment of inertia.

It would require too much space to describe all the other refined and ingenious contrivances which were applied by Professor Willis to secure the correct registration of the results. We must refer to the Report itself for an account of his methods of determining precisely the velocity of transit, and of applying tracing pencils at different points of the trial bar, so as to show the simultaneous deflections at those points during the whole transit.

We have no little gratification in finding that the *practical* results, deduced by the combination of his labours with the beautiful investigations of Professor Stokes, agree identically with those predicted in this *Journal* two years and a half ago, in the paper on *The Dynamical Deflection of Girders.* In the 'Cambridge Transactions' for the year 1849, Professor Stokes, after giving an analytical series for expressing the relation of the dynamical to the statical deflection, in terms of a quantity β, expressing the effect of centrifugal force, adds, "In practical cases this series is reduced to $1+\frac{1}{\beta}$. The latter term is the same as would be got by taking into account the centrifugal force, and substituting in the small term involving that force the radius of curvature of the equilibrium trajectory for the radius of curvature of the actual trajectory. The problem has been already considered in this manner by others by whom it has been attacked." The method here explained is precisely that which was given in this *Journal*, which contained the only other investigation of the problem published.

Professor Willis also gives numerical results for comparing the two kinds of deflection, which agree exactly with our own, except that he has given the ratios in decimals which we gave as vulgar fractions.

Both Professors Willis and Stokes object, however, to one conclusion in the "able paper by Mr. Cox." In the 'Cambridge Transactions,' Mr. Stokes's liberality of feeling towards other labourers in the fields of science, induces him to speak of the paper as one in which "the subject is treated in a very striking and original manner;" but he adds, that "among the sources of labouring force which can be employed in deflecting the bridge, Mr. Cox has omitted to consider the *vis viva* arising from the horizontal motion of the body:" and proceeds to show that taking the horizontal acceleration into account, it is *theoretically* possible that the deflection may be under certain circumstances more than double that which could be maintained statically.

Of this theoretical truth there can be no dispute, nor of the accuracy of the argument alleged in its support. A single observation however will be sufficient to remove the apparent discrepancy between the two independent investigations. That of Professor Stokes treated the subject in all its theoretical generality with the aid of all his analytical powers, and was addressed to a mathematical audience. The investigation of Mr. Cox was intended for practical engineers, and therefore regarded the subject with those limitations respecting the inertia of the beam which practice imposes. *When these limitations are introduced, the results of both papers are identical.* The opinion of Professor Willis is conclusive on this point: speaking of the paper in this *Journal*, he says:—"The author has employed methods of approximation which, although they have not apparently vitiated his results *as far as real bridges are concerned*, would cause them to fail utterly if applied to the interpretation of experiments such as those contained in the present volume."—That is, experiments in which the ratios of the mass of the beam and load altogether differ from those ordinarily adopted. Moreover, it is to be observed that the object of the paper in this *Journal* was the discussion of the deflection of the girder at the CENTRE; and for that point the conclusions of the paper still holds, even when the additional consideration of horizontal acceleration is introduced.

The observations are made not merely from personal feeling—for that would be amply gratified by the acknowledgment made of our labours—but also to show how materially the whole question is affected by the relation of the moving and sustaining masses.

Among the experiments in Portsmouth Dockyard we find a series for determining the deflection of bars, subjected to the "sudden application of weight without impact;" and another series for determining "the effects of a camber or upward convexity of the beam." Both these series, though the fact is not alluded to in the Report, were suggested in this *Journal*, by the paper above referred to, in the sections discussing the effects of *instantaneous loading* and the effects of *centrifugal force*: the experimental results amply confirm the conclusions arrived at in the paper.

The whole question of the dynamical deflection of girders must now be considered as set at rest. It is quite obvious that a thousand circumstances occur in practice which would vitiate all theoretical conclusions as to the very minute quantity which the excess of dynamical over statical deflection is shown to be. A very slight original curvature of the beam, its imperfect elasticity, a bad joint of the rails, the pulse of the engine even, would set all mathematics at defiance. However, a great service has been rendered by the investigation; the value of the result is in nowise diminished because it shows the effects of velocity to be inconsiderable. Next to security, the most important requirement of railway travelling is a conviction of security. It is the reasonableness of such a conviction, long ago demonstrated in these pages, which the admirable labours of Professors Stokes and Willis, Captain James and Lieutenant Galton, have elucidated by means of experimental induction.

SUPPLY OF WATER TO THE METROPOLIS.

On the means of Supplying the Metropolis with Pure Water and in ample quantity. By Mr. John Pym.—(Paper read at the Society of Arts.)

The author commenced by stating that the water supply of the metropolis is derived from three sources:—the New River, the Thames, and the Lea; wells sunk to different depths in the London clay, sand, and gravel; and Artesian wells. Of the water thus obtained, that from the Thames is impure, that of the New River almost as bad for a great part of the year, whilst many of the wells, being impregnated by drainage from burial-grounds or sewers, yield water of a decidedly pernicious quality. Artesian wells, that is, wells sunk through the London clay into the chalk, produce excellent water; but only of limited quantity, the supply failing in dry weather, and being seriously affected if a deeper well be sunk in the neighbourhood: indeed, it appears certain, that if all the water lying in the chalk of the London basin could be brought to the surface, it would fall short in quantity of that required. The question which the author proposes is, how to obtain a sufficient supply through the medium of these wells; and his plan is as follows:—At a given distance from the Thames, on each side thereof, to sink down to the chalk a series of shafts, and form a short canal from the mouth of each shaft to the bank of the river, at such a level that when the tide is at a given height, the water will flow into the shafts; whereby an immense supply would, twice a day, be given to the chalk basin. Other shafts are to be sunk at small distances from the former ones, up which the filtered water would rise, as into inverted syphons, till near the level of the Thames; and from these ascending-shafts it should be distributed by steam-power. By this plan, the chalk stratum of the London Basin, extending from Highgate to Forest Hill, would be converted into a large filter. A shaft of the diameter of those of the Thames Tunnel would probably filter a quantity of water equal to that supplied by the New River. The shafts might be converted into preparatory filter-beds by filling them with sand and gravel. The author considers that the water being thus quickly filtered through the chalk, would not become so impregnated with lime as the water usually got from Artesian wells, which has lain in it for a length of time. This plan would allow of the existing mains, pipes, &c., of the water companies being used as before.

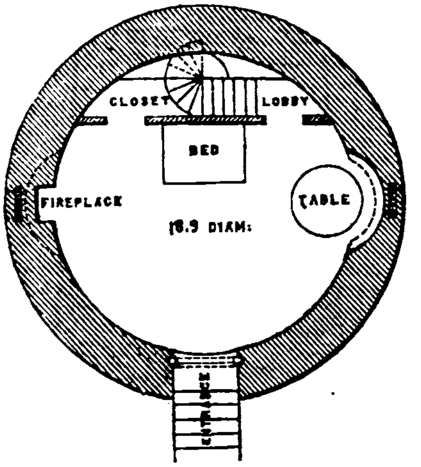
The author stated, as an example of the absorbing properties of the chalk, that farmers, on or near the outcrop of the chalk, frequently sunk shallow wells, which served as drains and removed a large portion of useless surface water.

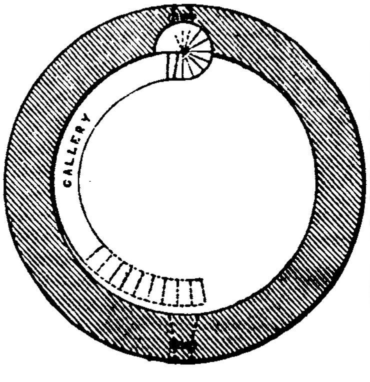
It was stated that the water from the Artesian wells contains three times the amount of chemical impurities of any of the waters from the streams around London: the water of the Lea contains twelve grains of lime to the gallon; but the water from Artesian wells, in addition to lime, contains sulphate and muriate of soda, &c.

THE BARROW MONUMENT, ULVERSTON.

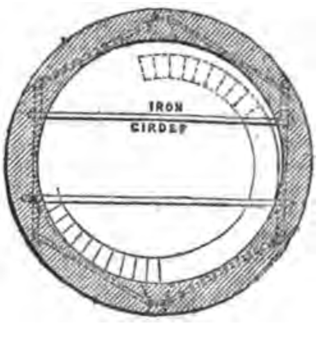
This interesting testimonial to the late Sir John Barrow has just been commenced in the immediate neighbourhood of his birthplace—Dragley Beck, near Ulverston. A public subscription was raised for the purpose, amounting to upwards of 1000*l*., and the whole is erected under the auspices of the Board of Admiralty. The type of the memorial, as will be seen in the elevation and section given in our next page, is to be found in the well-known Eddystone Lighthouse, and, like that stately beacon, it will be a highly serviceable sea-mark in the difficult and dangerous navigation of Morecambe Bay. The plan of the building is circular, about 45 ft. diameter at the base, and tapering gracefully to a lantern, 12 feet diameter, and finished by a dome. The extreme height is 100 feet. For the substantial walling the material used is known as "Trap" stone; the facings, &c. of Birkrigg limestone. A seat will encircle the foot of the tower at the exterior, and the various levels of the interior will be reached by a geometrical staircase. The highest room is intended for an observatory, and will be so constructed that it may at any time be easily converted into a lighthouse. The first stone was laid on the 15th inst. by Sir George Barrow (of the Admiralty), assisted by his brother, Mr. John Barrow, in the presence of a vast concourse of spectators. The design and superintendence are committed to Mr. Andrew Trimen, architect, of the Adelphi; and the contractors are Messrs. Smith and Appleford, also of London.

Plan A.





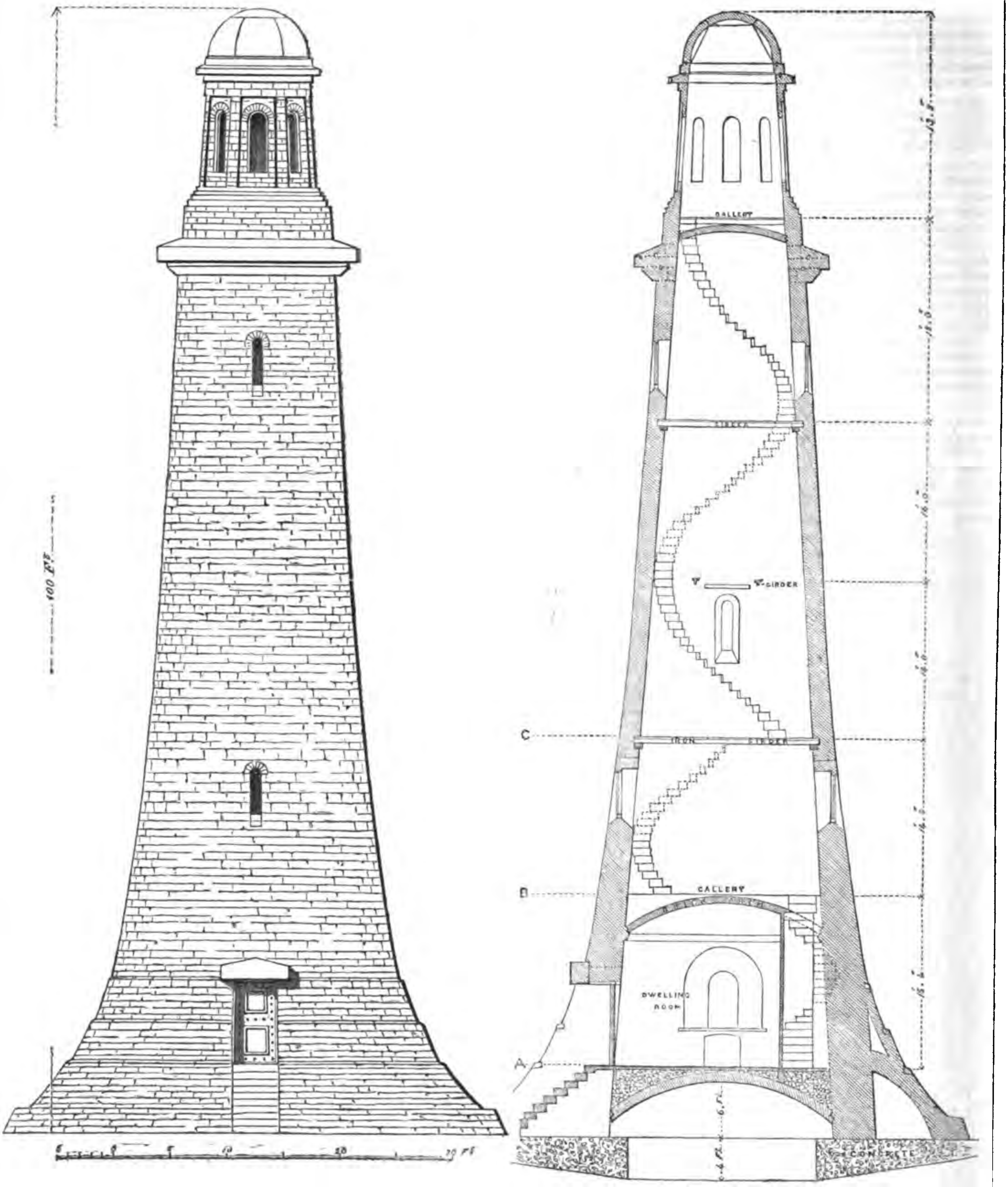
Plan B.



Plan C.

From the elevated position of the monument it will be conspicuous on all sides for a considerable distance. It has been ascertained that an unobstructed view of one of the finest bays in Europe, the Bay of Morecambe, from Green Odd round to the entrance of the Duddon, will be gained from the observatory of the Tower, with the exception of only about 1200 yards, which will be obscured by the highest point of Birkrigg. It also overlooks the Isle of Man, and the coast of Wales from Liverpool to Anglesea.

The ceremony was attended by every token of rejoicing; and a sumptuous dinner closed the festivities of the occasion.



ELEVATION.

SECTION.

THE BARROW MONUMENT, ULVERSTON, LANCASHIRE.

MR. ANDREW TRIMEN, ARCHITECT, LONDON.

PREPARATION AND APPLICATION OF GYPSUM.

On the Peculiar and Distinctive Character of the Gypsum found near Paris, and its Preparation and Application as a Plaster. By George R. Burnell, C.E.—(Paper read at the Royal Institute of British Architects, April 8th.)

Amongst the local advantages enjoyed by our professional brethren of the French capital. that afforded by the unlimited supply of a very superior description of plaster may be ranked as one of the most important. The facilities afforded by the railway, and steamboat, transit having at length put us (to a certain extent) upon a footing of equality in this matter with them, it becomes important to examine the nature of the material thus offered for our use.

Regarding plaster mechanically, it may be considered as a species of lime, which is susceptible of being employed without admixture with any other ingredient than water; and of attaining with singular rapidity, a moderate degree of hardness. These qualities would render its employment in all cases very desirable, were it of a nature to resist the influences of the atmosphere. But unfortunately it is utterly incapable of resisting the effects of humidity, when used alone.

Chemically, plaster may be defined, in a manner able to include all its varieties, as being a dehydrised sulphate of lime, or that salt from which the water of crystallisation has been driven off by heat. The sulphate of lime is very plentifully distributed through nature, in numerous positions, and in very large quantities. "It is found either crystallised, fibrous, massive, or earthy: the varieties which assume a definite crystallisation are distinguished by the name of selenite; those which are amorphous, or earthy, are known by that of gypsum: the names are, however, frequently confounded. When crystallised it assumes the form of a straight prism of a rhomboidal base, whose angles vary from 113° 5′ and 60° 3′, to 113° 3′, and 66° 52′, terminated by oblique angled prisms. The natural joints are very visible; the crystals are generally transparent with a shining pearly lustre; and are of various shades of white, yellow, grey, brown, red, or violet colour. Sulphate of lime ismuch softer than the carbonate, and it yields easily to the nail. Its specific gravity is about 2·31. When pure it contains 32·7 per cent. of lime; 46·3 of sulphuric acid; and 21 of water.

The crystallised selenite is found at Alston, in Cumberland, and in great abundance at Shotover-hill, in Oxfordshire. It also occurs in considerable quantities in all argillaceous deposits, in detached crystals, but hardly ever in veins. It is said occasionally to traverse fissures in the primary rocks accompanied by mineral veins. In Derbyshire, and some of the mines of the Hartz and Hungary, it is found in remarkably long slender fibres, which are generally associated and curved. At Matlock, a variety with straight fibres is met with, which is of remarkable brilliance and beauty.

The massive sulphate of lime is termed alabaster, on account of its resemblance to the material properly so called, although this is in fact a stalactical carbonate of lime. The real, or oriential, alabaster was much used by the ancients for the purpose of statuary, and was extracted in large quantities from the mountains of Upper Egypt. The variety of the sulphate of lime, which is at present used under that name, is principally obtained at Mount Cenis.

Granular massive gypsum is found overlying the most recent of the primitive rocks, and sometimes it is said, enclosed by them. It is found in Siberia mingled with mica, felspar, and serpentine; it occurs between two beds of gneiss near St. Gothard, and also at Bellinzina in the Alps, and also near the Mount Cenis; and at Moutier, near Mont Blanc. It generally accompanies the carbonate of lime formations; and is largely found in connection with the saliferous system. In Scotland, it covers the transition rocks; in Derbyshire and in the midland counties, the gypsum is also found in connection with, or contiguous to the salt rocks; in the north of Spain, and in Tuscany, the same co-relation is to be observed. The gypseous and saliferous formations of the Pyrenees are, equally with the analagous formations in England, of the secondary series; those of Tuscany are of the older pliocene era; whilst the most important deposits as the sulphate of lime, namely, those near Paris, are of the eocene formations, according to Sir C. Lyell's classification. It is, however, to be observed that the secondary strata, with which the gypseous rocks are connected in England, are of the early secondary divisions; whilst in Spain they are only found associated with the chalk, or occasionally with a formation similar to the tertiary sub-Appenine rocks.

The intimate connection which exists in the great majority of cases between the gypseous and the saliferous rocks, is a subject which appears to merit a more elaborate investigation than it has hitherto received. Whenever rock salt is met with, in either the secondary or the tertiary deposits, the gypsum always accompanies it, in an infinite variety of forms. It is true that in some cases the gypsum is met with unaccompanied by the salt; but then the absence of the latter would appear to be accidental, excepting in the Paris basin. The gypsum is found in the same positions; the rocks present the same appearance; and the strata have the same structure. For instance, at St. Léger sur Dhune, in the department of the Soane and Loire, the gypsum is found alone in the *marnes irisées*, or the upper new red sandstone and red marl of our technicology; they are also found near Aix, in Provence, in tertiary strata. But in both these cases they assume the forms, and all the lithological characteristics of the saliferous system; so much so in fact as almost to warrant the term of salt rocks without savour. The structure of the saliferous gypsums is undulated and mammillated; their texture is fine, compact, often crystalline, and they differ from what are considered as sedimentary deposits of gypsum, such as those of the environs of Paris, by a degree of whiteness, and purity from extraneous ingredients, which fully warrants the separate classification of the gypsums into those connected with the salt deposits, and those which are purely and simply sedimentary. One very remarkable appearance is presented by the saliferous variety which never occurs in the sedimentary; namely, we often find in it masses, the centre of which is composed of the anhydrous gypsum, whilst the exterior only has hydrated; as though the total mass had been formed in the anhydrous state, and the exterior had combined with the water at a subsequent period.

We have an excellent opportunity of tracing on a small scale the class of geological phenomena which accompanied the formation of the saliferous gypsum in the duchy of Tuscany. Near Volterra and Castellana, are found some of the purest of the false alabasters, which are principally worked at the latter district. It is found in glandular masses, enclosed in three beds of a greyish crystalline gypsum, which somewhat resembles the beds of the same nature near Paris. The masses found near Castellana are the purest, and present in the highest degree the whiteness and translucence which are sought for in the modern use of alabaster. At Volterra they are less pure, and are found dispersed in the grey and blueish marls, known under the name of "mattajone." These marls are very much contorted; and at Volterra itself they are inclined, and upraised. They belong to the sub-Appenine formations of the tertiary period; and occasionally they give rise to brine springs, which have led to the formation of large salt works.

The most remarkable feature of the saliferous formation of Tuscany is the purity and the mass of the gypsum. The whole formation is evidently stratified; whether we find the gypsum in detached rounded masses, with mamillary faces, enclosed in the beds of marl, and succeeding one another at irregular distances, in the direction of the stratification, like the nodules of septaria in the London clay; or whether it constitute thick beds intercallated between the marls, and exposed to all the accidents of stratification which affect them. In no cases are the marls affected by purturbations, or alternations, which might lead us to suppose that the gypsum had been introduced subsequently to their deposition. The gypsum is evidently stratified, and contemporaneous with the mattajone; the amygdalordal character of the nodules can then only be attributed to the affinity of the molecules, brought into action by specific causes which affected the waters in which they were in suspension.

The rock salt appears to be disposed like the gypsum, according to the lines of stratification of the whole formation, It is worked from wells; one of which, executed near the factory called "Moye," presents the following beds:—

	ft.	in.
1. Blue marl, containing nodules of alabaster, which is about (in thickness)	144	4
2. Rock salt	15	7
3. Marl, with gypsum	19	7½
4. Saliferous marl, about (in thickness)	14	1
5. Blue marl ,,	37	5
6. Saliferous marl ,,	29	6
7. Gypseous marl ,,	26	0
8. Rock salt, (greatest deposit) ,,	41	0
9. Blue marls ,,	166	8

Now the nature of the causes which led to this intercallation of the salt and gypsum between the strata of this formation (one of the most recent of the saliferous deposits), appears to be intimately connected with the existence of the lagoni of Tuscany, which are the last traces of a series of phenomena acting, in all probability, with much greater energy at the epoch of the deposition of the tertiary strata. These lagoni are eruptions of aqueous vapour at a temperature of 105 to 120 centrigrade. They burst forth with violence from fissures in the ground, and rise in white columns from 30 to 66 feet from the earth. They are accompanied by a strong odour of sulphuretted hydrogen; they alter the rocks they approach, and deposit in them crystalline or concreted gypsum, occasionally mixed with sulphur and boracic acid.

The lagoni are found in groups of from ten to thirty, nearly in a straight line extending from the Mount Cerboli, Castel Nuovo, and Monte Rotondo; as though they followed the direction of a fault, or dyke whose length is from 20 to 25 miles. The boracic acid they contain is extracted by means of the heat of the lagoni themselves, which are made to evaporate the waters drawn into basins for that purpose. But the most interesting geological fact connected with them is the influence their vapours appear to have in the formation of the sulphate of lime; which accumulates in small crystals, or in crystalline masses in the marls, and the calcarcerous strata they traverse.

If such lagoni had acted upon the gulfs or the lakes of salt water, of the tertiary period, it is easy to account for the alternations of the gypsum and the rock salt in the sedimentary deposits of that period. The gypsum, whether crystalline, in small beds, in mamillary, or botryoidal nodules, which are disseminated in the marl beds, would naturally result from the phenomena of affinity of which we find instances in almost every formation. The gypseous strata we may consider as representing the epochs of activity of the vapours, and of the disturbance of the waters; the saliferous strata would correspond with the epochs of tranquility, during which the evaporating powers of the jets exercised alone their influence. The presence of the borates of magnesia (which are sufficiently common in gypsums) may be explained also by the nature of the lagoni in actiivity at the present day.

The gypseous formation of Paris differs from all those we have hitherto considered on many accounts. Geologically a very marked distinction is to be made, inasmuch as from the manner of its formation, its stratification, and the shells it contains, we are led to believe that it was produced by mechanical deposition rather than by chemical separation, like the other formations. The rocks now to be examined form a portion of the immense tertiary deposits which fill a depression in the chalk, called, from the fact of Paris occupying its centre, the Paris basin. An adventitious interest is communicated to this formation from the fact of its having led M. M. Cuvier and Brogniart to propound the doctrine of the superior importance of the study of organic remains, to that of the lithological character of a deposit; a doctrine, it is true, previously propounded by our countryman Smith, but the superior knowledge of the French geologists in comparative anatomy, and conchology, placed the question beyond doubt. The Paris basin was the first which was distinctly classed as a tertiary formation, and the announcement of this clasification gave rise to the researches which led to the discovery of similar deposits in many other parts of Europe. There is also a chemical difference between the Paris gypsum and any of the saliferous gypsums hitherto noticed, viz.—that it contains as much as 12 per cent. of carbonate of lime in combination. This appears to communicate to it the much superior power it possesses of resisting atmospheric change. Another difference lies in the mechanical structure, for the Paris gypsum is the hardest known, except perhaps that found near Girgenti, in Sicily, which, according to Rondelet, a most conscientious authority, is still harder. We do not, however, possess any details on this subject.

The gypseous deposits near Paris form a very distinct and easily identified group, or subdivision, which comprehends (at the same time as the gypsum) alternating beds of marl, either calcareous or argillaceous. These beds follow an order precisely identical throughout the whole district, from the neighbourhood of Meaux to Meulan. Some beds are absent in particular cantons; but those which are still to be met with occupy the same relative positions.

The gypsum immediately overlies the calcareous beds Cuvier designated as the "calcaire marin;" and their appearance in the landscape in the neighbourhood of Paris is very remarkable, even in a picturesque point of view. They cap the hills of the older and harder formations; and appear to have suffered more severely from the denuding effects of the cataclasms which gave rise to the existing valleys, than the subjacent rocks. They thus form, as it were, a second range of hills (sometimes conical, as at Montmartre, Les Buttes Dorgemont; or elongated, as at Chaumont and Belleville, Triel, &c.) superposed on a first series of hills, bearing all the characteristic marks of the calcareous ranges.

We find at Montmartre and at Belleville, where the formation exists in the most perfect development, that there are three masses of gypsum of various thicknesses. The lowest mass, situated immediately upon the "calcaire marin" is composed of beds of gypsum of feeble thickness, containing a large proportion of selenitous, or crystallised gypsum, and alternating with beds of calcareous marl, of a very solid character, or with argillaceous marls in very thin flakes. Sometimes a deep bed of white fresh-water marl is interposed between the gypsum and the upper courses of the "calcaire marin." The number of the beds of gypsum in the lowest mass is five; their total thickness is not more than 7 ft. 7 in. This mass is seldom worked; for the double reason, that its extraction is very difficult, and the quality of the plaster it yields is decidedly inferior to that of the upper masses. But it is to be borne in mind, that the thickness and the number of the beds in the lowest mass are very variable. Those quoted above are obtained from the quarries called "L'Amerique," at Belleville; at Montmartre the total thickness of the beds of gypsum and the marls is from thirty-three to thirty-six feet, measuring from the upper bed of gypsum to the bed of white calcareous marl. There is, however, something exceptional in the nature of this third mass at Montmartre, inasmuch as it has never been observed to pass under the others, and it occurs in a detached hillock, rather towards the east. Its beds are not horizontal, but decidedly inclined towards the south-west.

The second and third masses are separated by a set of beds of marl, whose thickness is about five feet. Like the third mass, it is composed of a series of beds of gypsum, intercallated with marl in variable thicknesses, and without definite order; that is to say, that the marl beds are wanting in some localities, whilst they are very numerous and powerful in others. The greatest thickness which the second mass exhibits is met with in the quarries at Montmartre, where it sometimes attains as much as 33 feet. At Belleville, the height is, however, rarely more than 19ft. 6in.; and it affords eight workable and useful beds: the irregularities in the thickness appear to be, however, more owing to the beds of marl than to those of gypsum, which present a very striking uniformity. The second mass yields a stone which makes excellent plaster. One bed in particular, found at Belleville, and called by the quarrymen "le gros banc," three feet in thickness, is often set aside for the purpose of making plaster for the exclusive use of statuaries or artists.

The first mass is the most important, and also the most widely distributed. The lower masses are wanting in many localities, as at Triel, where the first mass rests immediately upon the marls and clays interposed between the first and second masses in Montmartre and Belleville. At Montmorency there are two masses; but in all cases the relative superiority of the first mass, both in quantity and freedom from mixture of the marl beds, is very remarkable. In some cases, as at Dammartin and Montmorency, this formation occurs immediately under the vegetable soil. At others, as at Belleville and at Montmartre, it is covered by a series of beds of sands, clays, argillaceous and calcareous marls, which attain as much as from 110 to 120 feet in thickness. A somewhat similar set of beds of marls and clays forms the floor, separating the first from the second masses of gypsum; its thickness is variable, but may be taken as being about 10 feet on the average.

The upper beds of the first mass are strongly impregnated with marl, and this latter substance even intercallates with the gypsum with sufficient regularity to enable us to follow the respective strata over great distances. They are soft; the workmen group them under the name of "les chiens;" and they yield a very inferior plaster if burnt alone. Their united thickness is about 5ft. 6in.; and they are six in number, in some of the quarries at least, never being fewer than five. The intermediate beds whose number and thickness is the most exposed to variations, are divided naturally into large many-sided prisms, which have procured for them the name of "les hauts piliers" among the quarrymen. Their united thickness is about 35 feet; the quality of the stone they yield differs somewhat, and care is requisite in the burning to secure a plaster of uniform quality. The bed called "la corraie," about 2 ft. 9 in. thick, is very hard, and it requires to be mixed with the softer beds to make a saleable article. Two others, "les battaillon" and "les rousses," are reserved for the special use of statuaries. The lowest beds of this mass contain much silex, which even at times seems to shade off as it were into the gypsum, without our being enabled to say precisely where the one begins or the other ends. The plaster made from them is of rather an inferior quality compared with that obtained from the intermediate beds.

The lowest mass contains at times, especially in the associated marls, marine fossils, and large crystals of selenitic gypsum. The second mass contains fossil remains of fish, without any other traces of animal life; the marls also contain at times kidney-shaped nodules of the sulphate of strontian. In the first mass are found the numerous remains of extinct birds, animals, plants, and shells, which render these formations so celebrated in a geological point of view. On the north of Paris they are preserved in the gypsum itself, and they retain a considerable degree of consistence, being only surrounded by a thin coat of marl. On the south of Paris, however, they are often found in the marl beds, and are then very friable. The fossils of mammalia are exclusively confined to the first mass, and in no instance are they met with in any of the lower divisions. In the lowest, fossil trees have been found, and fresh-water shells in remarkable abundance. Cuvier gives a list of fourteen extinct species of mammalia, three or four birds, three reptiles, and three or four species of fish: Lyell gives a much greater number.

Now, the immense development of these gypseous formations, and the total absence of any traces of salt throughout the whole extent, as well as the nature of the fossils they enclose, lead us to believe that they must have been deposited under different circumstances from those which gave rise to the saliferous gypsums. An examination of the phenomena connected with their probable geological history would lead us into discussions which might be considered out of place here. Those who may be desirous of studying the question more thoroughly are referred to Sir C. Lyell's 'Principles of Geology.' In the chapter upon the eocene formations of the Paris basin the question is fully treated, with the elegance, eloquence, the power of grouping facts, of adorning details, which in Sir C. Lyell's case gives to science all the charm of romance. Suffice it to say, that the present theory of geologists leads them to regard the great mass of gypsum, in this district, "as a purely fresh water deposit, produced by a river whose waters were highly charged with the sulphate of lime, somewhat like La Frume Salso, in Sicily."

The method of raising the plaster stone differs, of course, with the circumstances under which it is found; that is to say, it is sometimes got by means of open cuttings, or by galleries, worked either from the hill side or by wells. The peculiarly abrupt manner in which the spurs of gypsum terminate upon the heights round Paris, renders the mode of working from galleries driven into the hill face the most usual. At Montmartre, Triel, and Belleville, the quarries are all worked in that manner. The regulation of the quarries is, like everything else in France, subject to a very scientific and inquisitorial supervision on the part of the government. The service of the mines is under the control of a special body of engineers, called "Les Ingenieurs des Mines," who are charged to insure the public safety and the lives of the workmen, which might otherwise be compromised by the mining operations; to defend the rights of the state to the discovery of the precious metals; and subsidiarily to ascertain all geological facts which might influence the national wealth. The consequence of this organisation is, that the statistics of French geology, if such a term be allowed, are classified in the most wonderful manner; an instance of which, by the way, is to be found in the geological map and explanation published under the direction of M. Élie de Beaumont. However, quarries in open cutting are worked by the proprietors of the land, without any control on the part of the engineers of the mines; and they are simply under the control of the police. When they are under ground, the quarries are under the special control of the engineers, and the principles which regulate their working are those laid down by a decree of Napoleon's, dated March 2nd, 1813. Rigorously, the stone or gypsum quarries ought to be worked with something like the regularity of a chessboard; the galleries being 15 metres, or about 50 feet wide, with piers at equal distances of 10 metres, or 33 feet square. In practice this mathematical precision is neglected; but it may be considered as the average manner of working. The quarry-cap of the gypsum does not admit of being left with so wide a bearing as 50 feet, as might naturally be supposed. A small heading is then driven in the bed, called the "souchet," by a man lying flat on his back, for the bed is only 1 ft. 8 in. deep, who leaves the upper bed, "le banc be grand abattage," unsupported in this manner, for a width of 8 feet. For this very painful work the miner, called in this case the "caveur," is paid at about the rate of 1s. per foot forward; he finding his own picks, the proprietor the candles. The other beds are then raised by wedges, bars, or gunpowder, as may be required. A good quarryman can raise about 9 yards cube per day, of the first mass, and about 5¾ yards of the two lower masses, when the workings are in gallery.

We have before seen that the quality of the gypsum is not the same through the whole thickness of the different masses. Great care is then required in mixing the different sorts of stone, so as to secure an uniformity in the plaster obtained by the burning. Some of the beds are reserved for special uses; the hard beds, in the remaining portions, require to be mixed with the softer ones. As might naturally be expected this variety introduces a complication in the manufacture, which frequently gives rise to improper fabrication, and opens the door to much fraud. Indeed, the fabrication of plaster near Paris, still more in the departments, is liable to all the reproaches we so unsparingly address to our own cement manufactures. Such must always be the result of unlimited competition, and as long as price is made of more importance than quality such they will remain.

The mode of burning usually adopted is very rude. It consists simply in building, within three walls, covered with a rough fixed roof, a series of arches 1 ft. 8 in. wide by 2 ft. 4 in. high, with piers formed of gypseous stones, as are also the arches. These are then filled up to a height of 13 feet with stones, so arranged that the largest are at the bottom, the smallest at the top. The arches are filled in with fire-wood, which is set light to, and the fire kept up so as to maintain the baking for twenty-four hours. The dimensions of these kilns are such as to enable them to hold from seventy to seventy-five tons. In some of the quarries a more rational style of burning is adopted, which consists in passing the already pulverised stone through cylinders, which revolve in an open fire. I have, also, in one of Mr. Weale's Treatises, mentioned an application of over-heated steam to the same purpose; but the inquiries I made in Paris, about a month since, lead me to believe that it has not yet been fairly tried.

Indeed, there is always a difficulty in introducing any new process in the ordinary arts of life, such, for instance, as the one which meets us on the threshold in the use of the French plaster. Near Paris, the workmen have always been accustomed to employ plaster burnt in immediate contact with the wood. In that process the brees become necessarily mingled with it, and we find now that the men have come to consider the grey colour they communicate as an indication of a superior quality. The Paris workmen, in fact, do precisely the reverse to what our workmen do; upon the same principle, nevertheless, viz.—from an irreflective habit. They dislike a white plaster; we attach far too much importance to it. Truth, as in most cases, lies in the mean. The absence of the brees certainly does not diminish the value of the plaster; the extreme whiteness we contend for in London is for the most part obtained by the use of a softer description of stone, or by the admixture of some extraneous ingredient.

The operation of burning the plaster stone, is, after all, only effected for the purpose of dehydrising, or driving off the water of crystallisation from the gypsum. Before this is done, the stone is hard; afterwards, it becomes pulverulent and floury. The *rationale* of its use is, simply to present such a quantity of water as is necessary to restore it to the original state, when it resumes its natural hardness, with a commencement of a confused crystallisation. Now this action may be, and is, carried on irrespective of colour; that is to say, at least, the presence of the wood ashes, which gives rise to the grey tint the Paris workmen require, does not affect the combination with the water. Our own very white plasters owe their beautiful colour to the absence of the carbonates of lime, or the marls, which, in fact, communicate the very superior qualities to the stones yielding plaster less purely white.

To secure a good quality of plaster it is advisable to apply a moderate heat in the beginning, which is to be augmented gradually When the plaster is not sufficiently burned, it becomes dry and sandy; in this state it does not set with any degree of hardness. When it is overburnt, it also loses its adhesive properties; it ceases to have what the workmen call "de l'amour;" it will not cling to the fingers, nor has it the rich unctuous quality which characterises the well-burnt plaster. As soon as it is burnt, it should be ground, and employed as soon as possible after the manipulation is completed.

Fourcroy believed that the carbonate of lime contained in the Paris gypsum, became converted into quick lime during the burning; and that the superiority of that plaster was to be attributed to that change. Guy Lussac, however, held that the carbonate could not be affected by the moderate heat called into action (it is only absolutely required to be about 270 Fah.) He attributes the superiority rather to the great hardness of the stone; and really there does not appear to be any other explanation. We are aware that, *cæteris paribus*, the law exists, that the limestones yield limes producing mortars whose degree of hardness, when set, is in the ratio of the hardness of the stone. Nor does there appear to be any reason why the gypsums should differ from the carbonate of lime in this respect. Indeed, we find that the law holds good with the English gypsums, for the Derby stone makes a stronger plaster than that of Newark, just as it is harder than the latter. Dumas agrees with Guy Lussac, in supposing that no other chemical action takes place with the gypsum, than the evolution of its water of crystallisation.

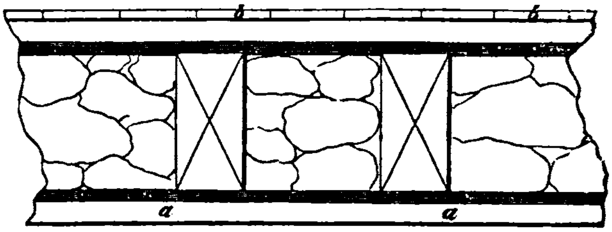
In Paris, the mode of using plaster is to employ it pure and free from mixture. The very low price at which it is sold, and the comparatively high price of sand, dispense with the motives of economy which render mixtures almost indispensable in our case. The town of Paris pays for its municipal works, at the rate of 12s. 9½d. per ton of plaster, whereas it cannot yet be had in London for less than about 40s. per ton. Whilst the practice in France is to use plaster pure, I am disposed to think that the mixture of sand, so far from being prejudicial, is even desirable, if confined within reasonable limits. We find that in reassuming the state of hydrated sulphate of lime, the plaster goes through an imperfect crystallisation; and this action is accompanied by a singular re-arrangement of the molecules. This causes the plaster to swell when used alone, and to such an extent, that it is impossible even to finish a ceiling close up to a wall at once. Now the introduction of a body so full of inequalities as the coarse, sharp sands, must afford room for the free action of this expansion; and, at the same time, the facettes of the sand must offer, as is were, nuclei, which cannot but be favourable to the crystallisation. It is, doubtlessly, on these principles that we can explain the superiority of the plaster containing the wood brees, which does become harder than the purer plasters, if used alone. Too large a proportion of sand should be avoided; but very fair work can be executed even with a mixture in the proportions of two of sand and one of plaster. Under any circumstances, the finishing coat should be pure. Subsequent experience will decide, whether the use of two materials of this kind does not expose the work to unequal contractions, likely to cause fissures, or cracks.

The plaster made near Paris sets with a rapidity very much greater than any material we are accustomed to for plastering purposes; and, for very large uniform surfaces, perhaps this is a difficulty. The workmen have not the time to work the floating coats with the mathematical correctness we usually exact in our country. But, to a certain extent, this objection may be obviated, by slight differences in the mode of preparing the plaster, or by altering the quantity of water in proportion to the positions in which the material is required to be used. Thus, if all the strength of the plaster is needed, the smallest quantity of water is introduced; about as much in bulk as the plaster itself occupied, This is called by the workmen, "gâcher serre" (stiff guaged). When it is necessary to work and re-work the face, as in setting coats, more water is added, or the plaster is said to be "gaché clair" (guaged thin). Habit alone can fix the precise proportions, for it is impossible to arrive constantly at the same results in the burning. For the very finest works, the workmen make what they call a "coulis;" this is run in, in a semi-fluid state. Plaster which has been thus treated, with an excess of water, does not acquire the tenacity, nor the hardness of that treated in such a way as only to present to it the water of crystallisation.

The extraordinary forces of adherence, &c., of the Paris plaster, enables the work on ceilings or partitions to be executed with far less expense of lathing than similar works executed with our lime and hair. Rondelet made experiments to ascertain the limits of these forces, and he obtained the following results:—A parallelopipedon of plaster, with a base measuring 1 in each way, supported a weight of 76lb., acting so as to tear it asunder; this he called the force of adhesion. Similar figures resisted a crushing weight of 722lb.; so that the ratio of the resistance of plaster to an effort of traction, compared to one of extension, is as 1·9½. Rondelet found that there was a sensible difference in the manner in which plaster adhered to brick or stone, from the action of mortar under similar circumstances. For, when cubes, joined by the respective materials, were subjected to forces tending to tear them asunder, the mortar broke through the centre of the joint, leaving particles attached to the upper and under surfaces; the plaster, on the contrary, left the surfaces perfectly clean. In new works, the plaster adheres to other materials, with about half the force necessary to tear it asunder: mortar, for several years at least, only attains one-third of the same force. This ratio does not continue; for, after ten or twelve years, the plaster loses its strength, whilst, at the same epoch, we find the adhesion of the mortar to other substances to be equal to the force of adhesion of the cubes themselves. The subsequent ratios are in inverse progression; mortar always hardens by time—plaster loses strength. As these remarks only apply to its use as a mortar externally, it should never be employed permanently for such positions; internally the loss of strength is not so rapid, for it depends upon the absorption of moisture from the atmosphere. For temporary works; for internal works, requiring great rapidity of execution, however, the use of Paris plaste is invaluable.

The usual practice in Paris (as I had the honour of observing in a paper I read last year), is to execute the work intended to be plastered with rubble stone, set in plaster mortar. If possible, the principal elevations are executed in ashlar; externally, plaster is never used if it can be avoided, for its use requires care and numerous precautions. Firstly, the plaster coat must be entirely out of the ground; it must be removed from all weatherings, where the capillary action would allow the absorption of water; the upper surfaces must be covered with zinc, or other metal; and, if it be expected to stand for many years, the whole must be painted. When, however, plaster is to be applied on walls, externally or internally, the course followed is to clear out the joints of the masonry, and to wet the surface. Plaster, gauged stiff, is laid on with a broom, or in any similar expeditious manner, and it is brought to a tolerably uniform face by use of the trowel. This is called 'faire le crepi,' a term equivalent to our "rendering." The floating coat, or 'l'enduit,' is applied by the trowel, and dressed off with a rule, in somewhat a similar manner to the system followed by our own workmen; but it is in the execution of this work that the greatest difficulty arises, from the rapidity with which the plaster sets. The stuff is gauged thin, but not sufficiently so to allow much manipulation. When the face is floated, as described, the plasterer passes over the surface with a sort of toothed trowel, called 'la truelle bretelée;' using, firstly, the toothed side, to remove any asperities, and finishing with the knife edge on the other. A thin setting coat is lastly added, to stop up all the pores or inequalities. The time required to complete such plastering on wall is very short compared with what we are accustomed to. The floating coat may be applied within four days of the rendering, under favourable conditions; and the whole work easily completed in a week.

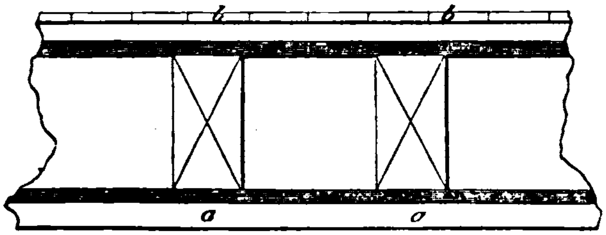
Partitions are usually executed in a manner essentially different from our own. A sort of wood frame-work is made, without much complication of carpentry, by the way, for the French, very wisely, prefer a wall where we too often place large trussed partitions. The French partitions rarely consist of more than upright posts, with stouter ones for doorways, and a few discharging braces, or horizontal ties. The upright posts, 'les poteaux,' are spaced about 1 ft. 4 in. apart; the door-posts are usually planed so as to form the architraves of the doors; they are called 'les poteaux d'huisserie.' Upon the common quarters laths are nailed (mostly of poplar, or fir), which are from 3 to 4 inches wide, and spaced about 4½ inches apart. The interior is filled in with old plaster rubble, or light stone, and the outer surfaces rendered, as for walling. Such partitions answer admirably for the purposes of keeping out sound, and are tolerably light. From the immense quantities of plaster rubble to be met with in Paris, they are also, comparatively speaking, economical. Close lathing is very rarely executed; nor, in fact, do the oak laths used in France allow such work to be well done. Some masons in Paris use a sort of tile, cast beforehand purposely for this use, and made of plaster. This system is not so solid as the usual one of only employing rubble, for the plaster does not adhere so well to the smooth faces of the tiles; but it avoids a very considerable amount of humidity.



(1) *Hourdé Plein.*

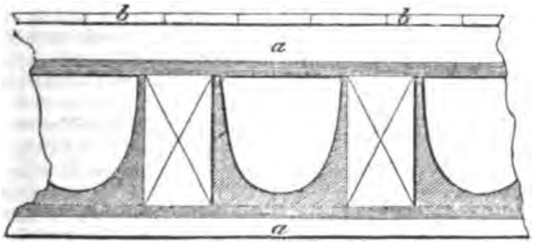
Ceilings are executed in several manners.—(1.) The space between the joists is filled in solid, with plaster, or stone, rubble carried on rather wide laths underneath; the lower surface is then rendered like a wall would be, and a bed is formed on the top to receive the tiles, or sleeper joists and flooring are added. This is said to be 'hourdé plein.'

(2.) With close lathing, as in England, 'à lattis jointif.'



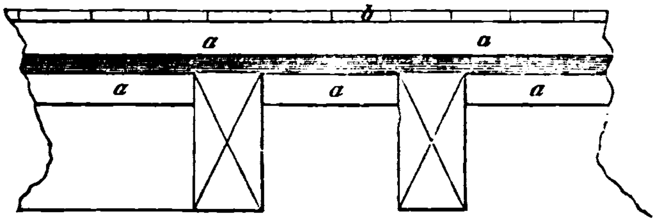
(2) *A Lattis Jointif.*

(3.) The third manner, and the one most usually adopted, because it binds the joists together the most effectually, without loading them unnecessarily, consists in lathing the underside of the joists at distances of about 3½ inches from centre to centre. A species of flat centering is then placed under them, and a coat of plaster of about 1¼ to 1½ inch is laid over the laths so as to stop against the boards on either side, and between them. The plaster is brought up the sides of the joists, and worked so as to leave a hollow channel. The ceiling itself is then applied below this coat, called an 'auget.'



(3) *Avec Augets, en Cannivaux.*

(4.) In the country, again, another manner is used, namely, the joists are left apparent, and only the intermediate spaces are ceiled. If the third manner could be adopted under the requisite conditions of economy, it would be very desirable, for it unites the great advantages of solidity and of impermeability to sound, in which respect our newly-built houses leave so much to be desired.



(4) *A Solives Apparentes.*

Note.—The parts shaded with parallel lines represent the laths; the blank parts *a a* represent the plaster; those marked *b b* represent the floor boards or tiles, as the case may be. No. 1 counts for the value of 1½ times No. 2. No. 2 constitutes the unity of price for common plastering—it is called "leger." Thus, No. 1 is said to be "1½ leger," and paid for at that rate. No. 3 counts for "1¼ leger." No. 4 counts also for "1½ leger."

Now, the proprietors of the French quarries have lately made arrangements by which the real plaster of, and from, Paris may be obtained in London at prices below those of our English plaster. Its use will, I am personally convinced, very soon supersede the barbarous mixtures of lime and hair, and all such trumpery, we have been forced to employ hitherto in its absence. A new application of any material is, however, always exposed to many risks and failures; from ignorance of its qualities, from unskilfulness in the handling, and even from the prejudices of those employed to execute the works. It may therefore be necessary to endeavour to point out the conditions requisite to ensure the successful essay of the one we are now considering.

Firstly. It is not advisable in the commonest sorts of work to allow more than two parts of sand to be mixed with one of plaster; for better works, one and one should be used. The setting coat should be of pure plaster; my own opinion is that large quantities of putty, or other preparation of the carbonate of lime, should not be used, though there does not appear to be any objection to the plaster being guaged with lime-water, which not only retards the setting, but also diminishes the expansion.

Secondly. My own experience with French workmen would lead me to say that we must not expect to be able to maintain, with a material which sets so rapidly as the plaster of Paris, surfaces so mathematically true as we do obtain in the usual system followed by our builders. In Paris, for several reasons, this exactness is not required; the rooms are smaller, it is not the fashion to have large unpannelled walls, or to use even, flat, tints. Small inequalities of surface are not, under such circumstances, of so much moment as they are to ourselves. Indeed we may form a tolerably corect idea of the comparative slovenliness with which plasterers' work is done there, from the fact that some of the workmen execute both it and the masonry on which it is applied. In all the buildings in Paris I have visited, the plastering has been executed with a carelessness which would disgust any London architect. The angles are never square, or true; the upright faces hardly ever "out of winding," or "plomb." Yet when our own more skilful workmen have overcome their prejudices, and learnt the proper use of this material, we have every reason to believe that they will make as perfectly "true" work with it as with the others. At the same time it attains in an incredibly short space of time a degree of hardness we are totally unused to, and it is accompanied by the immense advantage of only giving rise to about ⅜ths of the evaporation arising from ordinary plastering. A series of very careful experiments has been made under the directions of Messrs. Piper, which proves that the cost of ordinary works need not exceed in any sensible proportion, if at all, those we call usually "render, set:" that they are strictly the same as the render, float, and set; presenting a very superior article in every respect. Mr. Piper's experiments go to show that the evaporation from the French plaster is only about in the proportions just cited. In the Spicer Street Model Lodging Houses, Messrs. Piper executed, during the last week, a room which was begun and finished in thirty hours, whilst a common lime and hair rendering coat would have required a week at least ere it would have been fit to receive the floating coat, and the whole operation would have required, properly speaking, about a month. Mr. Beck, the architect, to whom all praise is due for the merit of the buildings in the first place, and for the sagacity which led him to try the new material, can vouch for the quality of the work, and explain the means adopted to obtain so very remarkable results. Subsequent experiments must, however, be made to ascertain the best mode of finishing superior work upon plaster rendering, either by the use of Keene's Parian, or Martin's cements; for it is my own perfect conviction that the use of lime and hair will very shortly be abandoned.

Thirdly. The French plaster must never be used in any position where moisture is likely to affect it for any length of time. It is very hygrometric, and soon decays if kept moist. The prevalence of warm moisture, as for instance in cellars, also gives rise to the formation of much saltpetre; its use in such places should then be avoided. The same faculty of forming the saltpetre should, also, make us very cautious as to the nature of the sand to be mixed with the plaster.

Fourthly. If the plaster be used as a mortar, for the purpose of carrying up bricknogged partitions to be covered over immediately, for which purpose, as said before, it would be invaluable, care must be taken to prevent the expansion of the plaster from affecting the other work. It is usual, in France, to leave a small space between the wall and the partitions, in carrying them up, which is subsequently filled-in by the plastering coat. The same observation applies to floors with plaster pugging, and even to cornices with a large body of that material. In the case of the latter, it is usual to run the straight mouldings, and to execute the mitres, or returns, subsequently. The projections of the cornices, by the way, are carried out solid, with very little, if any bracketing. But we must observe, that the French architects, very wisely, do not execute such terribly heavy internal decorations as we do, and that consequently their projections are less.

In the above remarks, I have studiously avoided the questions connected with the use of plaster in iron and pottery. They would have swelled this paper, already too long, to limits far beyond your patience. It is my intention to request your consideration of them upon some subsequent evening. In the mean time, we may be allowed to congratulate ourselves upon the fact, that the abolition of the excise upon bricks and tiles will enable us to make much more complete experiments.

I may add that the parties who have made arrangements for the sale of the French plaster in London, are Messrs. Piper of Bishopsgate-street, and Messrs. J. B. White and Sons, of Millbank-street. The price at which it can now be sold, is about 2*l.* per ton at the wharves.

WATER SUPPLY FOR LIVERPOOL.

Report *of* Robert Stephenson, C.E., *on the Supply of Water to the Town of Liverpool.*

The question which has been entrusted to me for my consideration and opinion, and on which I have now to report, is the best plan to be adopted for securing an adequate supply of water to the town of Liverpool; and in opening the subject, it will probably be most convenient and intelligible to introduce a copy of the Instructions conveyed in the Minute of the Water Committee of the Town Council, which is as follows:—

"At a meeting of the Water Committee, held on Monday, the 14th of January, 1850:—

Present:—James Procter, Esq., Chairman, &c., &c., &c.

"Read a letter from Mr. Stephenson, dated the 12th inst., and addressed to the Town Clerk.

"Resolved:—That the following instructions be communicated to Mr. Stephenson, and that he be respectfully requested to meet the Committee to-morrow morning at half-past nine o'clock.

"Mr. Stephenson having been unanimously appointed the Engineer for the purposes of the resolution of the Council of the 9th of November, the desire of the Committee is, that he should inform himself upon the subject in all its bearings, by evidence, reports, or otherwise, so as to ensure that the views of all parties may be elicited before him to their satisfaction, and report his opinion to the committee fully:—

"1st. Whether a supply sufficient as regards quantity and quality for the present and prospective wants of the town and neighbourhood, including domestic, trading, and manufacturing purposes, and shipping; and for public purposes, viz.—watering and cleansing streets, flushing sewers, extinguishing fires, and supplying public baths and wash-houses—can be obtained by additional borings and tunnels, or otherwise, at the present stations, viz.—those purchased from the companies respectively, and from the Green Lane Works, now vested in the Corporation; and the cost of obtaining such sufficient supply.

"2ndly. Whether a sufficient addition to the present supply can be obtained in the locality or neighbourhood of Liverpool, as recommended by Messrs. Simpson and Newlands, or by borings, or by any other course; and the cost of obtaining and distributing the same.

"3dly. Whether such supply can be obtained by means of the Rivington Works; and the cost of obtaining and distributing the same as recommended by Mr. Hawksley.

"4thly. Under all the present circumstances of the case, what course is recommended to be pursued?

"Extracted from the Proceedings.

"William Shuttleworth.

"Town Clerk."

In entering on the matter of the above resolutions, I feel it a pleasure to acknowledge the facilities which have been afforded by Mr. Newlands, the Borough Engineer, and those acting under him, both by supplying the necessary plans and by giving every means in their power for the examination and experiments at the pumping stations: and I also gladly avail myself of the opportunity to thank all who have assisted in the inquiry, either by offering their opinions and information in the public court, or in verbal or written communications.

There can be but one opinion respecting the great importance of an abundant supply of good water to such a town as Liverpool, for whether regarded in a sanitary or commercial point of view, there is, probably, nothing more conducive to the welfare and enjoyment of a large community.

In a sanitary point of view, the necessity of a large supply of water, in combination with a good system of sewerage, is now admitted on all hands;—the disposition evinced everywhere to place at the disposal of the poorer classes much larger quantities of water, and more convenient arrangements for their constant domestic supply, and to promote the general establishment of baths and wash-houses, sufficiently exhibit the strong prevailing feeling in this respect.

In a commercial point of view, both the quantity and the quality of the water supplied are also very important; in manufactures wherein water is used for the purpose of extracting vegetable or other principles from any substance; in the preparation of tea and coffee, in the saving of soap and labour in all detersive operations, in steam-engine boilers, and in economic processes generally, pure water has long been appreciated, and would no doubt be universally used where the expense of obtaining it is not too great. And when the influence of some small superiority of situation, or of the materials found or the facilities given on any spot, and the great extent to which competition now affects the profits of manufacturers are considered, the necessity is evident for taking especial care to secure every advantage that may present itself.

To Liverpool, in particular, with its high commercial position, its large and rapidly increasing population, and its immense constructions for the purposes of trade, science, and habitation, the advantage of a copious and permanent supply of good water can scarcely be over-rated.

These prominent considerations, with many others easy to mention, have led me to approach the subject with anxiety, and to devote to it my best energies. I trust the result may prove of advantage to the town and its community.

Supply from Wells.

In my inquiry, it was clearly necessary in the first instance to ascertain correctly the quantity of water yielded by the existing wells, the influence which they exert upon each other, and the mode by which the water contained in the mass of sandstone is transmitted from one place to another.

On this last and most important point the evidence adduced before me in Court was very conflicting, some of the witnesses maintaining, that however large a quantity might be pumped from one well, little or no effect was found to be produced upon those in the vicinity; and of this several well authenticated instances were certainly adduced, but a careful consideration of the whole mass of facts leads me to believe that these cases form rather the exception than the rule; and that they are occasioned by local geological faults, partially or wholly water tight, which are known to be interspersed throughout the new red sandstone formation in the neighbourhood of Liverpool.

It appears to me, also, that the purport of the evidence offered on this part of the subject was entirely misconceived by the parties who adduced it; for, it is evident that if the sandstone was so impermeable as to prevent one well influencing another at a moderate distance, it would be exceedingly difficult, if not absolutely impossible, to obtain a very large supply of water from any one well. As regards, indeed, the main question of obtaining from the sandstone an adequate supply of water, it is of the utmost consequence to establish indisputably that the sandstone is extremely permeable.

All the witnesses who have studied the structure of the formation on which Liverpool stands, concur in stating that it consists of a series of strata varying in permeability, and that large sheets of water may be conceived as spread out one above the other, being retained in their positions by intermediate beds more or less porous. Hence in sinking wells under ordinary circumstances, a gradual accession of water takes place as each succeeding stratum containing the sheets of water alluded to is intersected.

If this description of the structure represented truly the character of the sandstone, it is evident that wells would only affect each other when drawing water from the same series of strata; but there is a most important deviation from simple stratification in almost every part of the rock, from the existence of an infinite series of fissures, intersecting each other in every direction; a circumstance which obviously destroys the insulation between the sheets of water. These fissures are, by some, supposed to be filled with clay, and thus rendered impervious to water, which may be to some extent true; and it seems to be indicated by the circumstances already mentioned that wells in some cases are not found to act upon each other.

Dr. Buckland believes that some of these fissures are so extensive and so completely charged with clayey matters, as to divide the formation into a series of boxes. Mr. Rowlandson in his evidence dissents in a great measure from this view, and while admitting that fissures exist, he denies that they are quite impermeable, and to establish this, refers to the influence which one well exerts upon another. On this point he says, "I believe that those fractures are general, and in fact, that the water is diffused throughout the whole district through those cracks, and that therefore they are not filled with the impermeable clay." In this opinion I concur. Different degrees of porosity unquestionably exist, satisfactorily accounting in my mind for the different degrees of influence which wells are found to exert on each other. The facility with which the water will pass from one part of the sandstone to the other, depends principally on the size of the fissures, their character and their direction; and hence it is quite consistent with the existence of a very large number of fissures, that two wells at a great distance may affect each other while two that are near may show little or no connection.

The most extensive and the best established series of facts bearing on this part of the question are those surrounding Green Lane, which were laid before me by Mr. Bold. I think no one can examine the instances he records, of wells at great distances being immediately drained by pumping at Green Lane, without being struck by the remarkable facility with which the influence of the pumping is transmitted. If the cases adduced had been few and partial, one might have hesitated in admitting such easy permeability as I believe to exist; but the sympathy here evinced is at once so extensive, and the evidence so authentic, as to free my mind from all doubt.

It was urged, that the instances alluded to by Mr. Bold were only from shallow wells, and that the effect would not have been produced if they had been deep ones; but these wells cannot be truly stated as *all* shallow, nearly one half of them being from twenty to thirty-nine yards deep. This, however, does not strike me as of much importance, for if in both cases the easy diffusion, or the migration of water from one part of the formation to the other be equally well established, it matters not whether the wells be shallow or deep.

My opinion is that, in considering the question of the supply of water, the rock may be looked upon as almost equally permeable in every direction, and the whole mass regarded as a reservoir up to a certain level, to which, whenever wells are sunk, water will always be obtained, more or less abundantly; and a very careful consideration of the facts that have come to my knowledge in the present investigation leads me to consider this view as the simplest and the only one capable of general application.

Quantity of Water to be got from Wells.

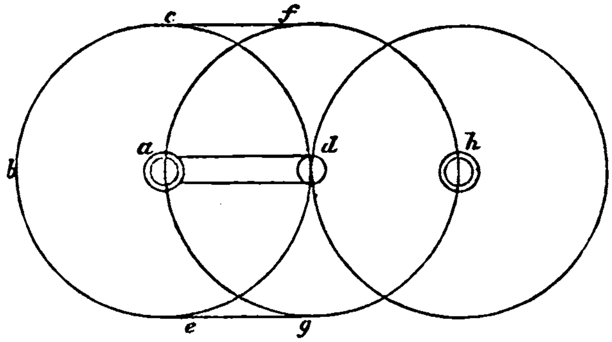
By thus recognising the permeability of the sandstone to a great extent, the question is relieved from many technical difficulties, which have caused much discussion without leading to any practical result. I shall, therefore, now assume that wells are sunk into that portion of the rock which is charged with water, and endeavour to ascertain what amount of water can be drawn from individual wells so circumstanced.

The effect of pumping from a well under such conditions will be to drain the adjacent rock, producing a comparative dryness on all sides, in such a manner as would be represented by an inverted cone; the bottom of the well being the apex of that cone, the sloping sides would represent the inclined surface of the water, flowing towards the well in all directions; and, as the pumping is continued, the sides of the cone will become more and more obtuse, or, in other words, more nearly horizontal, until an inclination is established where the friction of the water, in moving through the pores and fissures of the rock, is in equilibrium with the gravity upon the plane. And this condition of equilibrium once established, any further pumping power would be useless, as the water must gradually lower in the well until it is exhausted; and no additional power of pumping could then avail in increasing the quantity of water drawn from it.

The natural alternative under these circumstances is, to deepen the well by sinking a bore-hole, or to extend the filtering surface at its bottom by means of tunnels; and which of these methods is preferable has given rise to much difference of opinion. Where the pumping is periodical, the advantage of the tunnel or lodgment is unquestionably considerable, for it admits of the collection of a large body of water into these tunnels, as reservoirs, without causing much difference of level in the well itself; thus storing a quantity of water, in addition to what percolates gradually through the rock, which may be pumped out of the reservoirs, and with any rapidity.

Taking the view to be correct that the pumping from a well drains a conical mass of sandstone, until an equilibrium is established between the supply into the well and the draught from it, it would appear that the advantage of tunnelling is almost confined to its operation as a reservoir, for as the tunnel is extended it can only increase the drainage power of the well to the extent of a narrow band on each side of it, the slopes still corresponding with those of the side of the cone. Hence it is, I believe, demonstrable, that every attempt at increasing the yield of a well by tunnelling in the immediate vicinity of the well, can produce but limited permanent advantages.

In illustration of this, let us suppose that in the adjoining figure, a well is sunk at *a*, and that it drains an area represented by the circle *b c d e*, and that a tunnel is driven from *a* towards *d*, say one mile in length, and that another well is sunk at *d* upon the extremity or upon the terminus of this tunnel. The only effect of this would be to increase the drainage area of the well *a* by the area *f g h*, together with the small triangular spaces shown on the figure; whereas instead of the tunnel being driven from *a* to *d*, if the well at *d* had been sunk at *h*, the area drained would have been double that which was originally drained by *a*.



This method of looking upon the area drained by a well as represented on the surface by a circle is not strictly correct, because its form will be of course modified by the relative sizes, characters, and directions of the fissures through which the water finds its way to the well. The area represented by the circle in the figure will, therefore, most probably be very irregular in outline, but the way described by which the supply of water is transmitted to the well remains unchanged, and the conclusions to be derived from this reasoning may practically be depended on.

There is another defect in the system of tunnelling for the purpose of enlarging the supply of water at any great depth. Experience in Liverpool has clearly pointed out the necessity of, from time to time, deepening the wells in consequence of the increased demand upon them, and, with a system of tunnelling, the result would be similar, involving very great expense, and a most inconvenient operation. This inconvenience and expense has not hitherto operated with the public wells to any injurious extent, because the increase that has been made in them has not been considerable, but where we have to look forward to the utmost efforts being used to obtain the greatest possible supply of water from the sandstone at the fewest points, arrangements certainly ought to be contemplated for augmenting from time to time the supply at those points.

This view of the subject leads me to the opinion, that increasing the number of wells is likely to be a more permanent source of supply than extensive tunnelling, although the latter certainly admits of an easy mode of connecting the various sources of supply, and consequently of concentrating the whole of the pumping establishments.

Increase of Supply by Boring.

The other alternative for increasing the supply, namely, that of deepening the well, or of boring under it, has invariably been attended by an addition to the quantity of water yielded for at least some length of time; all the evidence which was given before me testifies that this may be safely reckoned upon. Let us now examine what would be the effect upon a well so deepened, with its increased amount of pumping.

It is clear that the space drained by the well before being deepened will now be increased in extent, and that an additional area will contribute water to the supply of the well; and this extension and consequent increase of the supply of water will proceed until the plane down which the water flows towards the well shall have attained nearly the same angle as was originally maintained by the shallower well—that is, the angle of equilibrium between the force of gravity and the friction in passing through the fissures. But the increase of supply to a well by deepening it, is by no means in proportion to the depth gained, as the supply is in all cases limited by the resistance which the water experiences in flowing towards the well through the fissures. It is, however, probable that a more permanent increase will be produced by deepening the wells than by constructing tunnels; a suggestion of course chiefly applicable to wells situated at a considerable distance from the River Mersey.

But all the public wells have already been sunk to the level of low-water mark, and from their proximity to the river it would, in my opinion, be inexpedient to increase the depth, either by sinking or boring, for if the sandstone be as pervious as I think it has been proved to be, a considerable amount of the supply to them would be derived from the river itself, and consequently the quality of the water much impaired.

There are numerous instances of wells having become brackish in the vicinity of the river; and, even at the distance of twelve hundred yards, Mr. McGregor's well, from long continued pumping below low water, has thus become charged in a remarkable manner with sea salt, and there are many other well-known instances all tending to establish the fact, that when wells, especially if near the river, are pumped below the level of low-water mark, the permeability of the sandstone is such as to admit of impure water flowing into them. And this result is in perfect accordance with the views I have explained, and corroborates the statement of the mode in which the sandstone is drained by the pumping in individual wells.

The Bootle Works.

All these circumstances point out the impropriety of relying much, or even to any extent, upon an increase from deepening the existing public wells. To this remark Bootle may perhaps be made an exception, as the level of the water at the works there is so much above high-water mark, and cannot for some time be reduced to it; but their proximity to the river is such that any considerable deepening, accompanied by the abstraction of much larger quantities than at present, would even in them be likely to be attended by an influx of water from the river.

The Bootle Works furnish a very good example of the free communication through the sandstone by fissures or otherwise, from the circumstance of the water in a quarry at a distance of about half a mile being much influenced in level by the rate of pumping at the Water Works. The foreman (John Prescott) states distinctly that the Bootle Quarry maintained the level of water at about 54 feet from the surface from the time of its being opened until the engines at Bootle commenced working night and day, when the level of the water sank to 60 feet from the surface; and that when this rate of pumping ceased and the water was allowed to accumulate in the reservoir at Bootle, a corresponding rise took place in the level of the water in the quarry, and prevented the works proceeding in the manner deemed most eligible.

The Bootle Works also afford a very interesting and instructive lesson as to the effect of bore-holes, and clearly demonstrate that the increase of their number with very varying depths does not regulate the quantity of water to be obtained by their means.

In the reservoirs at these works there are 16 bore-holes, each of them having been made for the purpose of supplying an additional quantity of water. Their efficiency was thus tested. The reservoirs having been pumped dry and all the bore-holes tightly plugged, the supply to the reservoirs when in this condition was small, consisting only of some leakage through the bottom, and what came from the engine well. The plug was then removed from a bore-hole 308 feet deep, and the yield was ascertained to be at the rate of 921,192 gallons per 24 hours. A second bore-hole 599 feet deep was next unplugged and the yield increased to 949,464 gallons; and so in succession each of the remaining bore-holes was unplugged until the whole were opened. By referring to Table No. 7 in the Appendix the result of each step of the experiment will be found recorded, and it will be observed that the total increase by opening 15 bore-holes amounted only to about 112,792 gallons per 24 hours, being little more than an addition of one-tenth to the yield when only the first was unplugged. But the first experiment, showing a yield of 921,192 gallons, although important, is not entirely free from objection, arising out of the circumstance of the passage of water from the plugged bore-holes through fissures in the rock between them and the lodgment or the engine well.

It may be inferred from the evidence of Thomas German the engine-man at Bootle, that as each successive bore-hole was put down an increase of water was at first obtained, and the circumstances attending one or two of them would lead to the supposition of the supply being derived from independent fissures; they are now, however, all more nearly in a state of equilibrium, and in effect deriving their supply from one common source. If a pump were applied to the first of the bore-holes which was unplugged and the water drawn from it as quickly as it flowed, the yield of the neighbouring bore-holes would immediately almost cease, their contents being absorbed by the pump; or if the arrangement be changed, the same amount of pumping power distributed amongst the entire number of bore-holes, each would yield a quantity similar to that which flows into the lodgments under the ordinary course of working. Every addition to the pumping power would equally lower the level of the water in each bore-hole, and these results could only be modified by the lateral communications between the bore-holes not being uniformly permeable, but it is evident from the above experiment, where the flow was interfered with so little by the majority of the bore-holes being plugged, that great uniformity exists in these channels of communication.

This group of bore-holes at Bootle presents a complete epitome of what is actually going on upon a large scale throughout the town of Liverpool. The difference is only one of degree, consisting in the intervention of a large mass of rock between the wells, which offers more difficulty to the free passage of water from one to the other.

Source of Supply.

But, before referring more particularly to the wells in the town, or their influence upon each other, I may state my idea generally as to the source of the supply, and the mode of its distribution in the sandstone.

I conceive that the source from which all the strata and fissures in the sandstone become charged, is the rain falling upon the surface of the surrounding country; that so soon as they are fully charged the surplus overflows and is discharged into the adjoining brooks and rivers; and that the rain which falls upon the surface and finds its way into the fissures, passes through apertures or channels of limited area, and will consequently form an inclined plane towards the easiest outfall, the angle of this plane with the horizon varying slightly, according to the wetness of the season. This view is illustrated by the outfall along the margin of the River Mersey, of a number of springs deriving their supply from the inclined plane of water which rises towards the high ground of Everton and Edge Hill; and such is generally the state of things when wells are first sunk. In order that a well should yield a supply of water at all seasons, it must be carried below the extreme fluctuations of the angles described; and the effect produced upon the plane by sinking a number of wells below it, and extracting water from them, would be to form a series of indentations, varying in depth and extent, according to the intensity of the draught and the permeability of the strata.

These views are somewhat similar to those expressed by Mr. Newlands and Mr. Rowlandson, and are corroborated by the elaborate sections of wells furnished by the former gentleman representing their depths with the usual level of the water in them.

Periodic Influences.

It is now necessary to advert to the theory of Mr. Gage respecting certain periodic influences to which he ascribes the rise and fall of the level of the water in the wells. For the purpose of illustration, he has favoured me with a section which shows the highest and lowest levels of the water during each week, from January 1846, to June 1847, which are prepared with care, and exhibit well the facts they represent.

I cannot, however, arrive at the same conclusions with him.

The first section, referring to the Soho station, shows, from January to March 1846, a gradual elevation of the level of the water, and from March to June, a gradual depression. Following the section, we find that from June to August, there is a considerable rise, which is no doubt attributable to the bore-hole made about that period, and probably to the fact stated by Mr. M'Donald, that the pumping at this station was not then so continuous as before, owing to the Windsor engine being worked for more hours. From August 1846, to January 1847, this elevation is very steadily maintained, but then declines to the following May and June, indicating, perhaps, to some extent, the falling off of the first accession of water from the bore-hole, which is stated to have been in progress between August 1846, and May 1847.

The general contour of the section, after the boring, certainly affords no proof of the periodic rise in March, broached by Mr. Gage; and as he does not give the weekly quantities pumped from the well, there are no data to show that the undulation in the levels did not arise simply from the abstraction of varying quantities of water during the periods to which reference is made. If there be any such influence, it appears to me that it would operate entirely against his opinion of the chief supply of water to the sandstone being derived from beneath. But this subject, although of considerable interest in a philosophical point of view has not really any important practical bearing upon the question before us.

In order, however, to ascertain the fluctuation which the level of the water does undergo in the different wells, I have prepared and given in the Appendix, sections for the year 1849, exhibiting the greatest and least heights, with the important addition of the quantities pumped out each week; thus affording an opportunity of judging whether the variations at different seasons are not truly ascribable to this cause. The examination of these sections has perfectly convinced me that the levels of the water in the several wells follow always an inverse ratio to the quantities of water abstracted. Taking the Soho station at the end of February, when the level was at the highest, it will be seen that the average weekly number of hours worked, for nine weeks equally distant from the end of February, amounted to 70½, and the average quantity to 2,300,510 gallons, whereas in the following month of June, when the level was lowest, the average number of hours per week for nine weeks amounted to 139¾, and the average quantity to 4,160,884 gallons, a cause quite sufficient in itself to account for the level of the water in the well subsiding without having recourse to any more abstruse reasoning. At the Water-street station the average work for thirteen weeks, extending over March, April, and May, was 65 hours per week, and the average quantity pumped 2,552,095 gallons, while the average of ten weeks over part of July, August, and September, was 84 hours per week, and the average quantity pumped 3,084,129 gallons.

These sections are, in my opinion, very informing when thus accompanied by the weekly quantities pumped from the wells. They show that, when the draught is equal to the supply, the general contour remains horizontal; that when the draught is increased this line declines, and again becomes horizontal when the equilibrium has re-established itself; and that the lower level begins to ascend immediately the quantity abstracted becomes reduced. It is therefore evident that the cause of the alterations in level is chiefly to be ascribed to the abstraction of different quantities of water by pumping.

A careful study of the facts which have now been referred to and explained has led me to the following conclusions:—

That an abundance of water is stored up in the new red sandstone, and may be obtained by sinking shafts and driving tunnels about the level of low water.

That the sandstone is very pervious, admitting of deep wells drawing their supply from distances exceeding one mile.

That the permeability of the sandstone is occasionally interfered with by faults or fissures filled with argillaceous matter, sometimes rendering them partially or wholly water-tight.

That neither by sinking, tunnelling or boring can the yield of any well be very materially and permanently increased, except so far as the contributing area may be thereby enlarged.

That the contributing area to any given well is limited by the amount of friction experienced by the movement of the water through the fissures and pores of the sandstone. And

That there is little or no probability of obtaining permanently more than about 1,000,000 or 1,200,000 gallons a-day, and this only when not interfered with by other deep wells.

(To be continued.)

ON THE SEWAGE OF TOWNS.

At the last meeting of the Royal Agricultural Society of England, Col. Grey informed the Council that this important subject had, along with the general interest it had lately excited in the public mind, become a matter of interest and study to his Royal Highness Prince Albert, and that he was commanded by his Royal Highness to bring before the Council of the Society, for their consideration and inquiry, should they think the subject worthy of it, what had struck his Royal Highness as being a simple plan for effecting the object in view. Leaving it to more competent judges to decide whether the sewage should be used as a liquid manure, or solidified, upon which point his Royal Highness wished to give no opinion himself, he had confined his consideration to the latter mode of application, for two reasons, namely, that in the solid form—

1. It could be more easily transported;
2. It could be obtained at the least possible expense.

Colonel Grey then proceeded to describe the plan proposed by his Royal Highness, which was simply this:—to form a tank, with a perforated false bottom, upon which a filtering medium should be laid; and to admit at one end the sewage into the tank, *below* the false bottom, when, according to the principle of water regaining its own level, the sewage liquid would rise through the filtering bed to its original level in the tank, and provided the filtering medium had been of the proper nature, and of sufficient thickness, it would be thus freed from all mechanical impurity, and would pass off into the drain, at the other end of the tank, as clean and clear as spring water. This simple and effective plan was illustrated by drawings, showing the vertical and horizontal sections of the tank, and by a neatly constructed model of its external form and internal arrangements. It was also clearly shown by these sections, how the sewage matter could be let into the tank, or shut off, when necessary, in the simplest manner, by means of common valves; and with what facility such a filtering tank might be applied to every existing arrangement of sewers without requiring any alteration in their structure. The filtering medium having abstracted from the sewage all extraneous matter, would, in all probability, become the richest manure, and could, at any time, by stopping the supply of sewage, be taken out by a common labourer with a shovel, and carted or shipped to any place thought most desirable. The solid matter, too, held in suspension by the sewage, would probably form a very rich deposit at the bottom of the tank, of a substance approaching in its qualities to guano, and could be extracted by removing the false bottom, which rested on arches or vertical supporters over the sewage below it in the tank, and could be easily made to lift up or take out for the purpose of such extraction. Two tanks might easily be constructed together, so that one might continue in operation while the other was being emptied. The experiment might be tried at any house-drain in town or country; in fact, his Royal Highness had himself tried the operation on a small scale with apparent success; and while he thus suggested an important and extensive application of the hydrostatical principle involved in the plan proposed, he wished to lay no claim to originality in the adoption of that well-known law of fluid bodies by which they make an effort, proportionate to their displacement, to regain their original equilibrium. On that principle was founded as he was well aware, the upward-filtering apparatus used by the Thames water companies. His Royal Highness's great object was by the simplest possible means to attain a great end; to effect an essential sanitary improvement, and at the same time to create a new source of national wealth by the very means employed for the removal of a deadly nuisance, and the conversion of decomposing matter highly noxious to animal life into the most powerful nutriment for vegetation.

His Royal Highness, too, wished to offer no opinion on the details required to complete the plan proposed, or on the mode of carrying it out in the most effective manner. Supposing it to be right in principle, its advantages in an economical point of view could only, his Royal Highness conceived, be ascertained by practical experience; and it was on that account that he wished to submit it to the consideration of the Agricultural Society, who might be better able to carry out the necessary experiments. It would remain to be decided what is chemically or mechanically the best and what the cheapest substance for the filter; what the best and cheapest construction of the tank; how long the sewage will pass before the filter becomes choked; and how soon the filter could be sufficiently saturated to make it profitable as a manure. His Royal Highness had used as the filtering medium, the following substances:—

1. Charcoal:—admitted to be the most perfect filtering substance for drinking water, retaining effectually extraneous matters, and well known for its singular powers of purification. 2. Gypsum (plaster of Paris, or sulphate of lime):—recommended by agricultural chemists for fixing ammonia and other volatile substances, by the decomposition to which it becomes subject when exposed to the action of volatile alkali. 3. Clay:—in its burnt state, would act mechanically as a filtering bed; and in its unburnt state, on account of its aluminous salts, has also the property, like gypsum, of fixing ammonia, or of decomposing the ammoniacal and other alkaline salts present in manure: and in either state would be cheaply procured.

All these substances, his Royal Highness thought, would in themselves be highly useful as manures, independently of the purpose they would subserve as agents for filtration, or for the additional amount of manuring matter they would receive from the sewage which they purified. His Royal Highness, however, in thus incidentally referring to the substances he had himself employed for the filtering medium, was well aware how many more of equal, if not superior, value, would suggest themselves to others, who, like himself, felt an interest in effecting the important object proposed. As he had given no opinion on the general question of liquid or solid application of manure, but had merely stated the grounds of preference, in a practical sense, of the solid form over the liquid for the purposes of the filtering operation under consideration, his Royal Highness entered into no discussion of the amount of manuring matter retained by the filter compared with the soluble matter that might pass through it along with the water, and remain in that liquid in a soluble, colourless, and transparent form; nor of the value of such filtered water for agricultural purposes.

EXPERIMENTS ON CAST IRON.

A Series *of* Experiments *on the* Comparative Strength *of different Kinds of* Cast Iron, *in their simple state as cast from the Pig, and also in their compounded state as Mixtures; made under the directions of* Robert Stephenson, Esq., *with a view to the selection of the most suitable for the various purposes required in the construction of the High Level Bridge.*

The bars were all cast from the same model, and as near as possible one inch square. They were all weighted on the centre of their length by a machine made expressly for testing the same, having a fixed distance of bearing of exactly three feet.

The experiments were conducted at Gateshead Iron Works between the months of September 1846, and February 1847.

The bars were all cast as near as practicable one inch square, those which were found to be defective in this respect were rejected previous to testing. If, however, upon the breaking of the bars and measuring across the section of fracture, any difference from the true size was discovered, it was noted in the remarks. When the difference was not appreciable by measurement it is stated "rather full in size;" when it was, the dimensions are given as $1\frac{1}{32}$ square, $1\frac{1}{16}$ wide, by $1\frac{1}{32}$ deep, and when this occurs, the breaking weights are reduced to one inch square.

Note.—From this point +, whenever it occurs, the weighting was continued by small shot, 7 pounds at a time, run from a cup containing that weight, until the bar broke, when if any remained in the cup it was weighed back.—B indicates the breaking weight.

HOT-BLAST IRON.

I. *Scotch—Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Metal mild and open in the grain at the centre of the bar.	406	·265	
	518	·36	
	630	·44	
	686	·51	
	B 742		
2. Fracture more close than No. 1.....	406	·31	
	518	·39	
	630	·495	
	686	·535	
	+ 742	·59	
	B 779	·655	
3. Close and uniform.	406	·315	
	518	·41	
	630	·54	
	686	·61	
	+ 742	·65	·065
	B 804	·74	

Mean breaking weight of the three bars, 775 lb.

II. *Coltness, No. 3.—Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Metal clear and even in texture; open; rather dark in colour.	406	·325	·027
	518	·43	·046
	630	·56	·07
	658	·59	
	+ 686	·63	
	B 851	·82	
2. Metal as No. 1..................	406	·35	·04
	518	·475	·07
	630	·62	·10
	+ 658	·665	
	B 708	·74	
3. Metal as above. This bar exceeded the size by $\frac{1}{16}$ in depth.	406	·30	·02
	518	·395	·03
	630	·51	·052
	658	·54	
	686	·575	
	714	·607	
	+ 742	·645	
	B 809		

Mean breaking weight of the three bars, 789 lb.

III *Langloan, No. 3.—Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Dull grey fracture................	406	·33	·025
	518	·44	·04
	630	·575	·07
	B 728	·66	
2. Better fracture than No. 1. Soft open fluid iron.	406	·31	·015
	518	·415	·025
	630	·53	·05
	+ 686	·595	
	B 768	·71	
3. Ditto	406	·33	·035
	518	·43	·055
	630	·56	·075
	B 686	·63	

Mean breaking weight of the three bars, 727 lb.

IV. *Omoa, No. 3.—Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Close even fracture. Colour darkish blue.	406	·29	·02
	518	·38	·03
	630	·48	·05
	686	·54	
	742	·60	
	+ 798	·67	
	B 940	·845	
2. Ditto	406	·30	·022
	518	·39	·035
	630	·49	·047
	686	·545	
	742	·605	
	798	·675	
	+ 826	·71	
	B 938	·86	
3. Appearance of fracture as preceding bars, Nos. 1 and 2.	406	·28	·015
	518	·36	·025
	630	·455	·04
	686	·52	
	742	·575	
	798	·64	
	+ 826	·67	
	B 840	·78	

Mean breaking weight of the three bars, 906 lb.

V. *Omoa, No. 1.—Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Colour dark soft, open, grey iron..	406	·33	·02
	518	·44	·04
	630	·565	·066
	658	·60	
	+ 686	·63	
	B 771	·75	
2. Bar full in size; metal as No. 1	406	·32	·015
	518	·397	·025
	630	·505	·035
	658	·535	
	686	·565	
	714	·60	
	+ 742	·635	
	B 840	·76	

Mean breaking weight of the two bars, 805 lb.

VI. *Redsdale, No. 3.—Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Fracture clean; colour light grey; free, kindly looking iron.	406	·28	·017
	518	·375	·03
	630	·47	·05
	686	·525	
	742	·58	
	798	·64	
	+ 826	·67	
	B1043	·96	
2. Ditto	406	·265	·01
	518	·35	·02
	630	·435	·03
	686	·485	
	742	·535	
	+ 798	·595	
	B 943	·76	
3. This bar was $1\frac{1}{16}$ deep; the breaking weight is given as reduced to one inch.	406	·25	·012
	518	·325	·015
	630	·41	·02
	686	·45	
	742	·50	
	798	·555	
	826	·585	
	+ 854	·615	
	1124	·95	
	B 1056		

Mean breaking weight of the three bars, 1014 lb.

VII. *Redsdale. No.* 1.—*Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Clear fracture; colour dark; soft, open grain iron.	406	·305	·025
	518	·405	·055
	630	·52	·072
	686	·60	
	742	·66	
	+ 770	·70	
	B 795	·725	
2. Ditto, as No. 1 bar	406	·317	·035
	518	·425	·065
	630	·545	·095
	686	·615	
	742	·69	
	B 809	·775	
3. Ditto, as Nos. 1 and 2	406	·315	·03
	518	·415	·05
	630	·54	·07
	686	·61	
	742	·685	
	+ 770	·723	
	B 777	·735	

Mean breaking weight of the three bars, 794 lb.

VIII. *Redsdale, No.* 1.—*Hot Blast. Bars cast from metal sent purposely for testing.*

	Weight applied in lbs.	Deflection.	Set.
1. Light grey colour; rather open in middle.	406	.32	·025
	518	·42	·04
	630	·54	·07
	+ 686	·61	
	B 934	·97	
2. Open clear metal, like to No. 1 bar..	406	·315	·03
	518	·425	·06
	630	·565	·07
	686	·635	·085
	742	·705	
	798	·78	
	B 826	·83	
3. This bar was $1\frac{1}{16}$ square; the metal of a clear bright fracture, like to the two preceding bars	406	·325	·03
	518	·425	·045
	630	·54	·065
	686	·605	·075
	742	·675	
	798	·75	
	+ 826	·79	
	B 996	·102	

Mean breaking weight of the three bars, 919 lb.

IX. *Tow-Law, No.* 3.—*Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Broke; short iron; light grey colour; mild and clear.	406	·35	·03
	518	·485	·06
	630	·645	·095
	B 686	·70	
2. Clear, good appearance, but evidently tender iron.	406	·37	·03
	518	·495	·045
	630	·585	·07
	+ 686	·715	
	B 731	·775	

Mean breaking weight of the two bars, 708 lb.

Average breaking weight of the preceding 25 bars, cast from nine sorts of hot-blast iron	826 lb.
Average ultimate deflection from 23 of the bars	·789 in.
Average permanent set acquired in 22 of the bars from a weight of 630 lb.	·066

COLD-BLAST IRON.

I. *Staffordshire, No.* 3.—*Cold Blast.* (*Number doubtful.*)

	Weight applied in lbs.	Deflection.	Set.
1. Colour dark; iron soft and open for No. 3 iron.	406	·305	·02
	518	·40	·035
	630	·51	·05
	686	·57	
	742	·64	
	+ 770	·675	
	B 867	·79	
2. Not quite so dark colour as No. 1 bar. Bar rather full in size.	406	·285	·015
	518	·37	·03
	630	·465	·035
	742	·59	
	770	·62	
	+ 798	·655	
	B 955	·85	
3. Similar fracture to No. 2 bar. Slight defect on bottom side.	406	·32	·02
	518	·42	·035
	630	·53	·065
	686	·59	
	742	·66	
	770	·70	
	B 798	·73	

Mean breaking weight of the three bars, 873 lb.

II. *Crawshay Welsh iron, No.* 1.—*Cold Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Clear bright fracture; metal open and free.	406	·295	·025
	518	·385	·045
	630	·49	·05
	686	·55	
	742	·62	
	+ 770	·655	
	B 900	·82	
2. Ditto, as No. 1 bar	406	·32	·025
	518	·42	·045
	630	·53	·06
	686	·60	
	742	·665	
	+ 770	·70	
	B 845	·81	
3. Bar slightly full in size; metal as in the preceding bars.	406	·275	·012
	518	·36	·03
	630	·465	·05
	686	·525	
	+ 714	·56	
	B 874	·77	

Mean breaking weight of the three bars, 873 lb.

III. *Blaenavon, No.* 1.—*Cold Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Colour dark grey; open free iron ..	406	·34	·035
	518	·46	·055
	630	·62	·095
	686	·715	
	B 742	·79	
2. Ditto as No. 1 bar................	406	·35	·037
	518	·465	·06
	630	·607	·105
	+ 686	·705	
	B 806	·91	
3 Ditto as No. 1 and 2 bars. Slight defect on under side.	406	·36	·045
	518	·485	·06
	630	·65	·11
	686	·735	
	B 714	·78	

Mean breaking weight of the three bars, 754 lb.

IV. *Coalbrook Vale, No.* 1.—*Cold Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Close dull fracture; defect in underside. Bar snapped suddenly.	406	·325	·012
	518	·42	·015
	630	·52	·03
	742	·635	
	B 784		
2. Clearer fracture than No. 1 iron; rather close for No. 1 quality.	406	·285	·015
	518	·38	·02
	630	·48	·03
	742	·58	
	+ 770	·61	
	B 905	·76	
3. Similar fracture to No. 2 bar; slight defect in upper side. Rather full in size.	406	·28	·015
	518	·37	·02
	630	·455	·025
	742	·555	
	+ 798	·615	
	B 938	·76	

Mean breaking weight of the three bars, 876 lb.

V. *Coalbrook Vale, No. 3.—Cold Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Light colour; close iron; slight defect on upper side. Bar rather full in size.	406	·30	·01
	518	·385	·015
	630	·48	·022
	742	·595	
	+ 798	·655	
	B 910	·77	
2. Fracture same in colour and appearance as No. 1 bar.	406	·285	·015
	518	·37	·017
	630	·455	·017
	742	·56	
	+ 798	·62	
	B 948	·775	
3. Similar fracture to No. 1 and 2 bars .	406	·28	·015
	518	·365	·025
	630	·455	·03
	742	·56	
	798	·62	
	+ 826	·65	
	B 833	·66	

Mean breaking weight of the three bars, 897 lb.

Average breaking weight of the preceding 15 bars, cast from five sorts of cold-blast iron	855 lb.
Average ultimate deflection from 14 of the bars	·784 in.
Average permanent set acquired from 15 of the bars, with a weight of 630 lb.	·051

MIXTURES OF IRONS.

Ystalyfera, No. 3.—Hot Blast. Anthracite. These bars do not rightly come under the head of mixtures, but are placed here from their peculiarity as being Anthracite iron.

1. Metal close, of even texture. Colour silvery grey.	406	·235	
	518	·265	
	630	·335	
	686	·43	
	+742	·48	
	B 877	·67	
2. Metal very close, fracture even. Colour silvery grey, as above.	406	·265	·000
	518	·345	·005
	630	·42	·005
	686	·465	
	742	·515	
	770	·53	
	+798	·57	
	B 1008	·77	
3. Metal as the preceding bars, in colour and appearance of fracture.	406	·265	·01
	518	·345	·01
	630	·425	·015
	686	·48	·025
	742	·535	·04
	770	·56	·04
	798	·595	·05
	+826	·62	·055
	B 998	·815	
4. Metal as above..................	406	·28	·015
	518	·37	·02
	630	·455	·02
	742	·55	·03
	798	·61	
	+826	·64	
	B 1036	·85	
5. Ditto as above	406	·25	·01
	518	·325	·017
	630	·407	·02
	686	·45	·025
	742	·495	·03
	798	·555	
	826	·575	
	+854	·60	·075
	B 1041	·79	
6. This bar being cast large, was filed on the sides to exactly one square inch, with a view to ascertain if the outer skin or crust was advantageous as to strength.	406	·255	·01
	518	·34	·025
	630	·415	·025
	686	·46	·035
	742	·515	
	798	·565	
	+854	·62	
	B 1026	·81	

Mean breaking weight of the six bars, 998 lb.

I. {*Ystalyfera, No. 3.—Anthracite* / *Blaenavon, No. 1.—Cold Blast*} *in equal proportions.*

	Weight applied in lbs.	Deflection.	Set.
1. Fracture uniform darkish grey; rather open.	406	·285	
	518	·375	
	630	·47	·03
	686	·535	
	+742	·605	
	B 892	·83	
2. Clear uniform fracture; rather closer than No. 1 bar.	406	·26	
	518	·35	
	630	·415	
	686	·51	
	742	·57	
	+798	·65	
	B 925	·84	
3. Clear iron; rather open, bluish grey	406	·325	·03
	518	·415	·05
	630	·54	·08
	686	·61	
	+742	·645	
	B 812	·80	

Mean breaking weight of the three bars, 876 lb.

II. {*Garscube, No. 1.—Hot Blast* / *Rededale, No. 3.—Hot Blast*} *in equal proportions.*

(No. 1 Cast of bars.)

1. Close grained, rather dark in colour.	406	·27	
	518	·335	·02
	630	·44	·035
	686	·49	
	+742	·55	·06
	B 991	·84	
2. Similar to No. 1 bar	406	·275	
	518	·365	
	630	·465	
	686	·52	
	742	·575	
	798	·635	
	+826	·68	
	B 971	·87	

Mean breaking weight of the two bars, 981 lb.

III. {*Garscube, No. 1 —Hot Blast* / *Rededale, No. 3.—Hot Blast*} *in equal proportions.*

(No. 2 Cast of bars)

1. Metal soft and open at centre of bar. Cast at an angle of 15°.	406	·305	·01
	518	·39	·025
	630	·495	
	686	·55	
	742	·61	
	+798	·675	
	B 812	·69	
2 More close than No. 1 bar. Cast at an angle of 15°.	406	·28	·015
	518	·37	·03
	630	·465	
	686	·52	
	742	·585	
	+798	·64	
	B 1000	·89	
3. Fracture like to No. 1 bar. Cast at an angle of 20°.	406	·28	·01
	518	·38	·015
	630	·485	
	686	·55	
	742	·615	
	+798	·675	
	B 910	·825	

Mean breaking weight of the three bars, 907 lb.

IV. {*Dundyvan, No. 3.—Hot Blast.* / *Coltness, No. 3.—Hot Blast.*} *in equal proportions.*

1. Mild open metal	406	·29	
	518	·385	
	630	·49	
	686	·55	
	742	·61	
	+770	·655	
	B 833	·725	

	Weight applied in lbs.	Deflection.	Set.
2. As No. 1 bar	406	·30	·015
	518	·395	·02
	630	·49	
	682	·545	
	742	·61	
	+770	·64	
	B 860	·74	
3. Clear good fracture, but evidently wants tenacity, from its breaking with so little deflection.	406	·325	·03
	518	·425	·04
	630	·52	
	658	·565	
	+686	·59	
	B 779	·68	

Mean breaking weight of the three bars, 824 lb.

V. *Rededale, No. 1.—Hot Blast* / *Clyde, No. 3.—Hot Blast* / *Coltness, No. 3.—Hot Blast* } *in equal proportions.*

1. Fracture clear and even; metal mild	406	·275	
	518	·375	
	630	·485	
	686	·55	
	742	·625	
	770	·675	
	+798	·705	
	B 876	·80	
2. Clear grey; metal rather open at centre of bar.	406	·315	·025
	518	·415	·05
	630	·53	
	686	·60	
	742	·67	
	+770	·71	
	B 887	·88	
3. Metal as No. 2 bar	406	·325	·02
	518	·425	·03
	630	·55	
	686	·625	
	714	·665	
	742	·70	
	+770	·73	
	B 815	·80	

Mean breaking weight of the three bars, 859 lb.

VI. *Langloan, No. 3.—Hot Blast* / *Omoa, No. 1.—Hot Blast* / *Forth, No. 3.—Hot Blast* } *in equal proportions.*

1. Dark bluish grey; rather soft. Bar sligh'ly defective on upper side.	406	·32	·025
	518	·425	·04
	630	·55	
	686	·62	
	714	·06	
	+742	·70	
	B 817	·805	
2. Metal as No. 1 bar	406	·33	·03
	518	·45	·045
	630	·58	
	686	·665	
	714	·70	
	+742	·74	
	B 847	·91	
3. Metal as No. 1 and 2 bars; dark in colour, and soft.	406	·32	·02
	518	·43	·035
	630	·56	
	686	·635	
	714	·675	
	+742	·715	
	B 824	·83	

Mean breaking weight of the three bars, 829 lb.

VII. *Omoa, Blair, Clyde, Langloan, Forth, and Coltness, all No. 3.—Hot Blast, in equal proportions.*

1. Fracture clear; would indicate good iron.	406	·27	
	518	·37	
	630	·47	
	686	·53	
	742	·59	
	B 798		

	Weight applied in lbs.	Deflection.	Set.
2. Fracture like to No. 1 bar	406	·265	
	518	·36	
	630	·45	
	686	·51	
	742	·56	
	+770	·62	
	B 965	·83	
3. Clear, uniform, and close; rather dark.	406	·3	·015
	518	·39	·025
	630	·485	·03
	742	·61	
	+798	·675	
	B 940	·84	

Mean breaking weight of the three bars, 901 lb.

VIII. *Scotch Hot Blast and Scrap, ordinary Foundry Mixture, for general purposes.*

1. Metal close; dull grey	406	·295	·015
	518	·375	·025
	630	·48	·037
	686	·54	·045
	742	·60	
	B 798	·665	
2. Fracture brighter than No. 1 bar ...	406	·295	·02
	518	·385	·026
	630	·49	·045
	686	·545	·052
	732	·605	
	+770	·635	
	B 909	·80	
3. Close and like to No. 2 bar. Bar full in size by nearly $\frac{1}{16}$ in depth.	406	·285	·015
	518	·37	·02
	630	·465	·035
	686	·525	·045
	742	·585	
	770	·61	
	+798	·64	
	B 929	·78	

Mean breaking weight of the three bars, 879 lb..

IX. *Carnbroe, No. 1.—Hot Blast* / *Rededale, No. 3.—Hot Blast* } *in equal proportions.*

1. Clear open; light colour	406	·31	·017
	518	·40	·017
	630	·50	·025
	686	·56	
	B 714	·595	
2. As No. 1 bar. Lighter colour than than the Coltness and Langloan bars.	406	·30	·02
	518	·39	·025
	630	·49	·04
	+686	·545	
	B 720	·59	

Mean breaking weight of the two bars, 717 lb.

X. *Same iron as No. 9, with an addition of one-third of Scrap iron. (The Scrap would be principally Cold Blast.)*

1. Metal free to work. Fracture clear and bright.	406	·265	
	518	·355	
	630	·44	
	686	·49	
	742	·545	
	770	·585	
	+798	·605	
	B 826	·64	
2. As No. 1 bar	406	·25	
	518	·33	
	630	·415	
	686	·46	
	742	·52	
	770	·545	
	+798	·57	
	B 920	·685	
3. As No. 1 and 2 bars	406	·27	
	518	·35	
	630	·435	
	686	·49	
	742	·54	
	770	·57	
	+798	·59	
	B 933	·72	

Mean breaking weight of the three bars, 893 lb.

XI. { *Crawshay (Welsh) No.* 1—*Cold Blast* / *Coalbrook-dale, No.* 1—*Cold Blast* } *in equal proportions.*

	Weight applied in lbs.	Deflection.	Set.
1. Grey; free open metal	406	·3	
	518	·39	
	630	·50	
	686	·58	
	742	·65	
	+770	·71	
	B 937	·96	
2. Metal dark-bluish grey; soft and open at centre of bar.	406	·33	·04
	518	·44	·05
	630	·58	·08
	686	·66	
	+714	·70	
	B 766	·775	
3 Metal as No. 2 bar...............	406	·31	·02
	518	·415	·03
	630	·55	
	686	·62	
	714	·665	
	+742	·71	
	B 880	·92	
4. As preceding bars, dark and open ..	406	·34	·03
	518	·45	·05
	630	·585	
	686	·67	
	+714	·715	
	B 837	·92	

Mean breaking weight of the four bars, 855 lb.

XII. *The Scrap iron used was principally old mill castings, such as shafts, hammers, rolls, &c., chiefly of Welsh Cold blast iron.*

Ystalyfera, No. 3—Anthracite	40 parts	Mixture of iron selected for casting the arch ribs of the High Level Bridge.
Redsdale, No. 3—Hot Blast	40 "	
Crawshay, No. 1, Cold Blast..........	40 "	
Blaenavon, No. 1—Cold Blast	30 "	
Coalbrook-dale, No. 1—Cold Blast....	30 "	
Scrap, selected (clean)	30 "	

FIRST CAST.

	Weight applied in lbs.	Deflection.	Set.
1. Defective near the centre of bearing, thus:  (Half size), short of metal in casting.	406	·25	·012
	518	·345	·015
	630	·425	·03
	686	·48	·042
	742	·535	·05
	798	·58	
	826	·61	
	B 854	·65	
2. Defective in like manner to No. 1 bar. Metal clear, close grained, and even.	406	·28	·012
	518	·37	·017
	630	·45	·003
	686	·496	·004
	742	·545	
	798	·605	
	+826	·635	
	B 886	·70	

Mean breaking weight of the two bars, 870 lb.

SECOND CAST.

	Weight applied in lbs.	Deflection.	Set.
1. Colour dullish grey. Fracture close and even.	406	·25	·005
	518	·32	·015
	630	·402	·025
	686	·45	·035
	742	·50	·045
	770	·525	
	798	·55	
	+826	·575	
	B 1043	·80	
2. Light silvery grey colour; close grained and uniform. Bar full in size, 1$\frac{1}{16}$ wide by 1$\frac{1}{32}$ deep. Breaking weight, 1060, reduced to one inch square.	406	·24	·005
	518	·315	·015
	630	·387	·02
	686	·43	·03
	742	·48	·04
	798	·525	
	826	·547	
	854	·575	
	+882	·60	
	1198	·965	
3. Fracture as No. 2 bar, in colour, &c. Bar full in size, 1$\frac{1}{16}$ wide by 1 deep. Breaking weight, 1072, reduced to inch square.	406	·24	·005
	518	·31	·01
	630	·39	·02
	686	·435	·025
	742	·48	·003
	798	·535	
	826	·555	
	854	·59	
	882	·615	
	+910	·64	
	1144	·915	

Mean breaking weight of the three bars, 1058 lb.

XIII. *Second melting, from the metal of a defective rib-piece, without any addition of new "pig."*

	Weight applied in lbs.	Deflection.	Set.
1. White metal; fracture crystalline;" very hard; and radiating thus:— 	406	·195	·00
	B 518	·25	·00
	406	·203	·00
	518	·255	·00
	532	·265	·00
	B 546	·27	·00
	406	·215	·00
	B 518	·27	·00

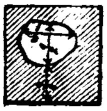
XIV. *Metal same as No.* 12 *selected for the bridge ribs. (Bars cast by Abbot and Co.)*

CAST FROM THE CUPOLA.

	Weight applied in lbs.	Deflection.	Set.
1. Bar very defective on top side. Metal dull, grey, close, and uniform.	406	·29	·015
	518	·375	·025
	630	·47	·03
	686	·53	·045
	742	·59	
	798	·65	
	826	·685	
	+854	·72	
	B 884	·76	
2. Iron close and uniform, of a dull light grey colour.	406	·29	·02
	518	·37	·025
	630	·475	·032
	686	·535	·64
	742	·595	
	798	·66	
	826	·695	
	+854	·73	
	B 928	·84	

Mean breaking weight of the two bars, 906 lb.

CAST FROM THE AIR FURNACE.

	Weight applied in lbs.	Deflection.	Set.
1. Iron very similar in colour and appearance to the two preceding bars.	406	·28	·02
	518	·365	·025
	630	·465	·04
	686	·52	·05
	742	·575	
	798	·635	
	826	·67	
	+854	·70	
	B 1023	·94	
2. Bar very defective, or the result would have been very great. 	406	·27	·015
	518	·355	·022
	630	·46	·035
	686	·52	·055
	742	·585	
	798	·65	
	826	·685	
	+854	·72	
	B 891	·77	

Mean breaking weight of the two bars, 957 lb.

XV. *Mixture for Railway Chairs.*

$\frac{1}{6}$*th part Crawshay, No.* 1—*Cold Blast.*
$\frac{1}{3}$*rd part Redsdale, No.* 3—*Hot Blast.*
$\frac{3}{6}$*th part Scotch, No.* 1 *and* 3—*Hot Blast.*

	Weight applied in lbs.	Deflection.	Set.
1. Metal mild and open, of a dark bluish-grey. Slight defect on top of bar. Bar rather full in size.	406	·315	·025
	518	·42	·04
	630	·54	·065
	686	·62	·075
	742	·70	
	770	·74	
	+798	·795	
	B 835	·86	

	Weight applied in lbs.	Deflection.	Set.
2. Metal as No. 1 bar................	406	·33	·03
	518	·45	·045
	630	·60	·085
	686	·69	·115
	742	·765	
	+770	·83	
	B 807	·91	
3. Metal shade lighter than No. 1 and 2 bars.	406	·295	·025
	518	·40	·05
	630	·53	·08
	686	·605	·10
	742	·685	
	770	·73	
	+798	·78	
	B 823	·84	

Mean breaking weight of the three bars, 822 lb.

XVI. *Mixture for Railway Chairs.*

⅙th part Crawshay, No. 1—Cold Blast.
½ part Rededale, No. 3—Hot Blast.
⅓rd part Scotch, No. 1 and 3—Hot Blast.

	Weight applied in lbs.	Deflection.	Set.
1. Dark grey; uniform texture........	406	·27	·012
	518	·35	·02
	630	·435	·03
	686	·485	·04
	742	·54	
	798	·60	
	826	·625	
	+854	·655	
	B 951	·77	
2. Metal dull grey, as above; close and uniform.	406	·27	·017
	518	·36	·025
	630	·455	·035
	686	·51	·05
	742	·565	
	798	·625	
	826	·66	
	+854	·69	
	B 944	·80	
3. Metal as No. 1 and 2 bars.........	406	·295	·015
	518	·38	·035
	630	·48	·04
	686	·535	·05
	742	·595	
	798	·635	
	826	·665	
	854	·685	
	+882	·715	
	B 889	·72	

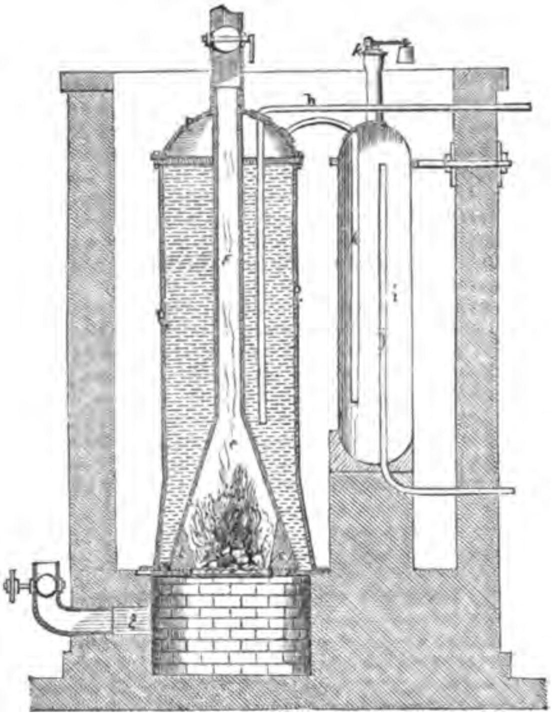
Mean breaking weight of the three bars, 928 lb.

REGISTER OF NEW PATENTS.

STEAM BOILERS.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for "*an invention of certain improvements in steam boilers.*" (A communication.)—Granted August 23, 1849; Enrolled February 23, 1850. [Reported in *Newton's London Journal.*]

The annexed engraving represents, in longitudinal vertical section, a boiler constructed according to the present invention; *a*, the fire-place; *b*, the fire-bars, surrounded by a wall of fire-bricks *c*, built upon a ledge or platform *p*, made of sheet or wrought-iron, and set in the masonry. The wall of fire-bricks thus forms a kind of shallow well, the bottom of which is formed by the fire-bars *b*. Fuel is supplied to the fire-place through an opening in front. The upper part *e*, of the fire-place, where the heat from the fuel is developed, is made conical, with an aperture at the top for the escape of the non-combustible gases up the flue *f*. The water of the boiler surrounds this conical fire-chamber and vertical flue; and the effect of this arrangement is, that the greater portion of the rays of heat, which radiate from the incandescent fuel, impinge against the sides of the cone, and are absorbed by the water which surrounds the same; while the rest are reflected back upon the fuel, and the heat in the fire-place is thereby very considerably increased; so that, as the combustible gases are evolved from the fuel, they are immediately consumed, instead of passing into the flue or chimney and escaping uselessly into the atmosphere. The conical chamber *e*, and the flue *f*, leading therefrom, the inventor prefers to construct of sheet copper,—that metal being a much better conductor of heat than iron. *g*, is the outer casing of the boiler, made of sheet-iron, and surrounded on all sides by a bed of sand, or other bad conductor of heat, for the purpose of preventing, as far as possible, loss of caloric by radiation. The boiler is, by means of a supply-pipe *h*, kept nearly full of water, as shown; and the steam that is generated in the boiler passes therefrom through a pipe *k*, into the steam-chamber *i*, wherein any water that may come over with the steam will be deposited; and only dry steam will be allowed to pass from the upper part of the vessel *i*, down the steam-pipe *j*, to the engine. The steam-chamber *i*, is furnished with a safety-valve k^1, and the upper end of the flue or chimney *f*, is provided with a throttle-valve, for the purpose of regulating the draft. Air, to support combustion, is supplied by the pipe *l*, to the ash-pit, where it becomes warmed before it acts upon the fuel. When it is requisite to remove the conical chamber *e*, and copper flue *f*, and replace these parts by new ones, the top or cover g^1, of the boiler is first removed; the base of the cone *e*, is then detached from the cast-iron platform *p*, and the feeding aperture *d*, from the sides of the vessel *g*; after which, the flue *f*, and conical chamber *e*, are free to be lifted out, without deranging or displacing anything else, and a new chamber *e*, may be readily adapted to the boiler.



In order to set forth with clearness the nature of his improvements, the inventor makes the following observations on the principle of the generation of steam:—"It is based," he says, "upon the difference in density or temperature of two bodies—viz., the incandescent fuel and the water, which have always a tendency to balance themselves or maintain an equilibrium. Thus, in order to maintain a given expansive force of steam, certain conditions are necessary—viz., first, the combustion of a given quantity of fuel in the fire-place; second, a certain temperature of the fluids in the flue or chimney must be maintained, dependent of course upon the temperature required in the boiler; third, the metal, of which the inner parts *e*, and *f*, of the boiler are constructed, and which transmit the caloric from the fire to the water, must be one of the best conductors of heat, and be placed in a condition to conduct the heat as quickly as possible from the fire to the water; and fourth, the metal of which the outer part of the boiler is constructed should be preserved as much as possible from radiating or conducting away the caloric. The above conditions are necessary, because the volume of steam will correspond to the volume or quantity of fuel employed; and upon the temperature maintained in the chamber *e*, and chimney *f*, will depend the rapidity with which heat will be transmitted and steam can be produced; the quicker and more powerful the transmission of caloric may be, the less extent of surface will be required: the pressure in the boiler will correspond with, or be in proportion to, the temperature of the water; and this pressure will increase or diminish as the temperature of the water increases or diminishes. Now, the rays of heat being divergent, and the temperature of the gases, which pass off by the orifice of the chimney, being in direct proportion to the intensity of the fire, or equal to that of the steam contained in the boiler, we may conclude that the heating surface of the chamber *e*, and flue *f*, is more than sufficient to take up and transmit the largest quantity of caloric which can be given out by the fire; and that the speed with which this heating surface transmits the caloric to the water is equal to the rapidity with which caloric is given off from the incandescent fuel; and further, that the practice of using the large extent of heating surface, which it has always hitherto been considered necessary to employ, in constructing steam-boilers or generators, is not derived from a principle or natural law, but merely from a rule laid down by constructors and engineers, and admitted *a priori*."

The patentee claims the combination, with a vertical flue, of a conical fire-place or enlarged heating chamber at the lower part of the same, or any mere modification thereof; whereby the intensity of the fire in the fire-place may be greatly increased by a portion of the caloric given out from the incandescent fuel being reflected back upon the fuel or combustible gases in the enlarged heating-chamber; and which fuel and combustible gases are thereby more effectually and economically consumed than in steam-boiler furnaces, with a more extended heating surface and less intensity of heat.

RAILWAY WHEELS.

Enoch Chambers, of Birmingham, smith, for "*improvements in the manufacture of wheels.*"—Granted November 10, 1849; Enrolled May 10, 1850.

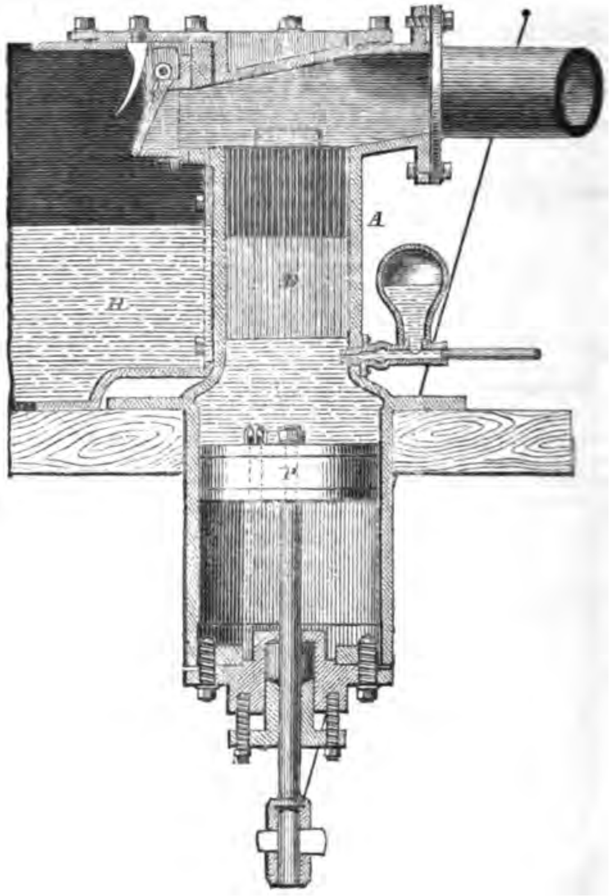
Wheels made according to this invention are each first made up into two halves, each half consisting of one half of the ring or felloe, one half the spokes, and one-half of the nave, all of wrought-iron, and the parts of a wheel are made in the following manner:—For each half of the nave a block or plate of iron is forged in a cylindrical exterior frame, with a flange or projection all round, and this flange or projection is to be drawn out by forging, so as to form projecting pieces at those parts in the circumference where the spokes are to be welded on. In the wheel shown in the drawings which accompany the specification there are eight spokes, four on each half-wheel, and in all cases this construction of wheel requires to have an even number of spokes, half being affixed or welded to one-half of the nave, and the other half of the spokes being fixed to the other half of the nave, and the spokes being placed in such relative positions that those of the one half shall come into the spaces between those of the other half. The projection or flange being thus drawn out or forged at intervals on each half of the nave of an intended wheel, so as to produce proper projections for the purpose of receiving the spokes; the spokes are to be welded on, each spoke having a portion of the ring or felloe of the wheel forged thereon, the alternate portions of the felloe or ring being on the two half naves respectively; so that when the two are brought together, and the inner surfaces of the two half naves are brought together, they will form the wheel. The two half naves are to be brought to a welding heat, and being placed one on the other in the position above described, are to be welded together by a suitable hammer or press. The patentee prefers to use a steam hammer for this purpose; and the parts of the felloe or ring of the wheel where they come together are also to be welded, and the tyre is to be shrunk on, and the wheel completed. The centre of the nave of the wheel is to be cut or turned out, and made suitable to receive the axle-tree, as shown, and as is well understood. Instead of welding the spokes and part of the felloe to the half naves before welding the half naves together, the spokes and parts of the felloe may be welded on afterwards, but the former method is preferred. In the preceding description special reference is had to railway wheels, but the same method of construction is equally applicable to wheels for common-road carriages and wagons.

Claims.—1. The manufacture of wheels by first making the nave in two parts (divided vertically) each having half the number of spokes, with a portion of the felloe attached to each spoke, and then welding together, the said two half naves, after which the tyre is shrunk on as usual.—2. The making of wrought iron naves with two flanges, each to receive, and have welded thereto, one half of the spokes of which a wheel is to be composed.

SIEMENS'S REGENERATIVE CONDENSER.

On Siemens's Patent Regenerative Condenser. By Mr. C. W. Siemens, of Birmingham. (Paper read at the Society of Arts, May 15th; Robert Stephenson, Esq., M.P., V.P., in the Chair.)

The paper commences with a historical sketch of the Condenser of the Steam-engine, from the invention of Savery, in which a single vessel served the triple purpose of steam-cylinder, condenser, and water-pump, to James Watt's injection condenser. Hornblower proposed a surface-condenser, which was, however, deficient in extent of cooling surface, and therefore failed, as have many others invented since; the most prominent being that of Mr. Samuel Hall, in which the steam was passed through tubes immersed in a stream of cold water. This condenser has the serious drawbacks of weight, costliness, and difficulty of getting rid of the calcareous deposits from the condensed steam.



Three years ago Mr. Siemens invented his surface-condenser for a situation where economy of space and material was essential. It consists of a number of copper plates $\frac{3}{32}$-inch in thickness, $4\frac{1}{2}$ inches broad, and 2 feet long, which are piled together with two longitudinal flattened wires of the same metal intervening between the adjacent plates, the whole pile being screwed up tight together between the sides of a rectangular cast-iron vessel, constituting the body of the condenser. The ends of the plates project through the top and bottom of the vessel, and are planed flush with its exterior surfaces. The joints are at top and bottom, secured by means of india-rubber rings, screwed down under small cast-iron frames, and which yield to the difference in expansion of the two metals. The flattened wires are laid parallel, and about three inches apart, and form, with the plates, a large number of narrow passages, through which the cold condensing water flows in an upward direction without entering the vacuous space of the condenser, into which the ends of the plates outside the flattened wires—forming the condensing surfaces—project. The heat of the steam is thus passed through the plates, from their edges towards the centre, to the condensing water,—the limit to its efficiency being the conducting power of the metal.

The essential features of this invention are its comparative cheapness of construction, the easy access it affords to the water-channels, and reduction in the quantity of condensing-water required. Its dimensions are as follows:—

Heat-absorbing surface by the the water .	18 sq. feet per H.P.
Condensing surface	9 do. do.
Thickness of metal through which the heat is conducted	1¼ inch.
Weight of copper	60 lb. per H.P.
Space occupied by plates	·4 cube feet per H.P.; or $\frac{1}{10}$th part of the space occupied by the tubes in Hall's condenser.

Encouraged by the success of this condenser, Mr. Siemens has directed his attention to the achievement of a still more important object, which is to condense the steam in such a manner, that the *condensing water issues into the hot well at boiling heat*, and yet produces an *efficient vacuum* within the working cylinder. This appears paradoxical at first sight, yet it has been succesfully accomplished by a perfectly new principle, called by Mr. Siemens the 'Regenerative Principle of Condensation.' It consists of a rectangular trunk A, of cast-iron, the lower end of which is cylindrical, and contains a working piston P, which performs two strokes for each one of the engine. In the trunk is a set of copper plates B, upright and parallel to each other,—the intervening spaces being the same as the thickness of the plates, viz.—between $\frac{1}{12}$th and $\frac{1}{16}$th of an inch.

The upper extremity of the condenser communicates on one side to the exhaust-port of the engine, and on the other through a valve V, to the hot-well H.

The plates are fastened together by five or more thin bolts, with small distance-washers between each plate. There is a lid at the top of the trunk, by removing which the set of plates can be lifted out. Immediately below the plates the injection-pipe enters.

The action of the condenser is as follows:—Motion is given to the piston by the engine, causing it to effect two strokes for every one of the engine. At the moment that the exhaust-port of the engine opens, the plates are completely immersed in water, a little of which has entered the passage above the plates, and is, together with the air present, carried off by the rush of steam into the hot-well, the excess of steam escaping into the atmosphere. The water then, in consequence of the downward motion of the piston, recedes between the plates, exposing them gradually to the steam, which condenses on them. Their upper edges emerging first from the receding water are surrounded by steam of atmospheric pressure, and become rapidly heated to about 210°. The emersion of the plates still continuing, the steam is constantly brought into contact with fresh cool surface, by which the greater portion of it is condensed, until, as the piston descends, the injection enters and completes the vacuum. This is done by the time the working piston of the engine has accomplished ¼th of its stroke. The upper extremities of the plates become heated to near 210°, and the lower to about 160°.

Taking the initial temperature of the condensing water at 60°, the final temperature at 210°, the latent heat of steam at 212° 960 units, the quantity of water required is 6·6 lb. to condense 1 lb. of steam of atmospheric pressure. The common injection condenser (supposing the temperature of the condensed steam to be 110°) requires 21·2 lb. in place of 6·6 lb.

The advantages of this condenser are:—

1. Additional effective power gained on account of the vacuum = 30 per cent. taking the pressure of steam at 40 lb. above the atmosphere, and vacuum in the cylinder 12 lb.
2. Heat saved in generating steam by the use of boiling feed-water = 10 per cent. over the ordinary method of heating the feed-water to 110°, or 15 per cent. when no use is made of the condensed water for that purpose.
3. The steam which escapes uncondensed may be used to cause draught.
4. The displacing cylinder takes no motive power.
5. The condenser may be started and stopped at any time by turning the injection water on or off. If turned on, it at once forms the vacuum without involving the necessity of blowing through; and if turned off, it allows the engine to proceed as though it had not a condenser.
6. The air contained in the condenser is at each stroke completely expelled.
7. Greater compactness, and less expense, than the injection condenser.

Its dimensions in terms of parts of the engine are as follows:—Area of plate-chamber = three times that of exhaust-pipe; length of plates = ¼ that of stroke of engine; thickness of plates $\frac{1}{300}$ of their length; spaces between plates same as thickness, but never more than $\frac{1}{16}$th of an inch, as with that dimension no sediment can stand against the rush of water. Capacity of displacing cylinder = that of plate chamber.

It has been attempted to adapt this condenser to the locomotive; and of the advantages which would be gained if this could be done there can be no doubt. In this case the two condensers were cast in one piece, and placed directly in front of the cylinders. They differed from that just described only in the length of the condenser and stroke of the displacing piston being much shortened; so that the velocity of the water between the plates may not be too great; and in having a second set of discharge-valves of peculiar construction for allowing the uncondensed steam to pass freely into the funnel. The ordinary supply of feed-water not being by itself sufficient to maintain the vacuum, this condenser, if applied to locomotives, should only be worked at intervals, on inclines &c., where its assistance would be needed.

In its application to low-pressure engines, since the steam from the cylinder has not sufficient power to force the air and heated water from the condenser into the atmosphere, a communication is made between the exhaust-valve of the condenser and the lower end of the displacing cylinder, which, for convenience of arrangement, is here reversed, and which receives the charge of water and air when its piston is at the opposite end of it, and when it is therefore vacuous.

In this case the amount of injection-water is reduced in the proportion of three to one. Ten per cent. is saved by the feed-water being made boiling hot, a great quantity of boiling water being provided which cannot fail to be useful for many purposes.

The first Regenerative Condenser was applied to a sixteen horse-power high-pressure engine, at Saltby Works, near Birmingham, in September 1849, where it has been found to answer. One is now being erected at the Paper Works of Messrs. Easton and Amos, at Wandsworth, and will shortly be in action.

A drawing was exhibited, showing the condenser applied to a common high-pressure engine, in connexion with a variable expansion valve, acted on by a governor, which is a modification of Mr. Siemen's chronometric governor, the pendulum being superseded by an expanding fly-wheel.

The principle involved in the Regenerative Condenser is applicable to many useful purposes, the most remarkable of which are what Mr. Siemens proposes to call his Regenerative Evaporator for brine and other liquids, and the Regenerative Engine, which are now in course of construction at the works of Messrs Fox and Henderson, near Birmingham, to whose enterprise Mr. Siemens expresses himself as indebted for the carrying out of his several inventions.

After the reading of the paper, a discussion took place, chiefly as to the practicability of applying the condenser to locomotives, in which Mr. Scott Russell, Mr. Crampton, and the author took part. It was closed by the Chairman, who said that the circumstances of the locomotive were so peculiar, the requirements of the most perfect simplicity, and the freedom from any but the most necessary dead weight so absolute that he feared this could not be applied to it, even if, which he doubted, the condensation could take place rapidly enough where the cylinder was filled and emptied four times in one second. But the principle was new to him, and certainly ingenious, as were the other inventions of Mr. Siemens; and in its application to stationary engines he hoped and believed his ingenuity would meet its due reward.

ON THE CONSTRUCTION OF ARCHES WITH HOLLOW CAST-IRON VOUSSOIRS.

In the construction of cast-iron bridges, it has generally been the practice to form a framework by means of ribs stretching across the full span in one or more pieces, in the form of an arch or otherwise, which ribs are stiffened and kept steady by transverse beams, diagonal struts, and ties; thus adopting to a certain extent the system followed in the construction of many of the wooden framed bridges, previous to the introduction of iron in being wholly used for such works. This, no doubt, is a very excellent mode of construction; but it is considered that by adopting the system of stone bridges, and having the voussoirs formed of cast-iron and hollow, a cheaper and easier constructed bridge could be erected; while the principle is one which possesses many peculiar advantages, and admits of being applied not only to arches of small, but also to those of very large spans.

In the framed system the ribs, beams, &c., are generally very heavy, require much workmanship in their construction, are difficult to cast, and after good castings have been obtained are very liable to be damaged before being put in their places; thus causing the reconstruction of other castings, and consequently adding much to the expense, on account of the risk and delay. By the proposed system the castings become of an ordinary nature, require less workmanship, are easier constructed, very light and easily handled, and run less risk of being damaged; and even when a number of the voussoirs were damaged, the contingent expense would be very little compared to that arising from the loss caused by the damage of a large and massive beam. Such castings are consequently cheaper executed, the cost per ton for the same kind of castings being frequently not much more than one-half that of the other; besides, by a judicious arrangement and economy, no more, or at least very little additional, metal need be required by the proposed than by the framed system.

Both in ancient and modern times, hollow bricks have been used in the construction of arches, especially where lightness was required, and no great weight to be sustained; as these bricks were liable to be easily crushed. With cast-iron this is, however, not the case, it being to a very great extent incompressible, the crushing weight for a square inch of cast-iron being 140,000lb., while good stock bricks require only 12,000lb. to crush it, and in stone the crushing weight varies, according to the quality, from 3166lb. to 6250lb. per square inch. Since hollow bricks have been successfully employed, it is easy to conceive that hollow voussoirs formed of such a hard and incompressible material as cast-iron, may likewise successfully be employed, not only for arches of a small but also for those of a very large span.

It is now an established principle, that when the materials of which an arch is composed are hard enough to resis tcompression, and the abutments sufficiently strong to resist being crushed or forced aside, there is no particular limit to the extent to which, if properly constructed, the span may not be carried. Of course, no substance being incompressible, it follows that there must be a limit beyond which the arch would destroy itself, but that limit will be greater or less according to the hardness of the material employed in the construction. An arch constructed of granite is capable of being carried to a greater span than one of good free-stone, and still more so than one of freestone of an inferior quality, or of brick not sufficiently fired. And following out the same principle with hollow cast-iron voussoirs, a still greater span could be accomplished than with any of these other materials.

Besides the advantage of cast-iron voussoirs, on account of its extreme hardness it possesses another advantage, that of lightness, these voussoirs being capable of being made sufficiently lighter than the same constructed of stone, and still retain sufficient strength to resist the required pressure. The weight of material in a cast-iron arch would be from ¼th to ⅙th that of a stone one, supposing the depth of the voussoirs was made the same in each, which however would not always be necessary, as when constructed of iron less depth would be sufficient, on account of its extreme hardness, the weight being so considerably diminished, and the pressure being more uniform over the entire surface of the joint: the surface of castings being much smoother and evener than that of an arch stone, which except in very particular cases is generally only neatly hammer-dressed.

Again, in the framed system usually adopted, the pressure is thrown on a very small surface, which is not the case in the proposed system; likewise the use of malleable iron is entirely avoided, it being purely a cast-iron arch, every part of which contributes its due proportion of resistance; forming a firm and compact mass, and possessing all the advantages of a stone arch.

Taking into consideration these many advantages—namely, the extreme hardness of the material employed, the decrease of weight and the superiority of the joint compared to stone arches, and the large extent of bearing surface compared to that of the framed system, it is surely not unreasonable to say that an arch on this principle may not only be carried to a greater extent than any hitherto constructed of stone, but equally as far, and perhaps further, than any that have yet been constructed of iron on the framed system. In the Grosvenor-bridge, across the River Dee at Chester, a stone arch has been succesfully thrown over a span of 200 feet. And in the Southwark-bridge, across the Thames at London, which is formed of cast-iron on the framed principle, the centre arch is carried to the extent of 240 feet; but with hollow cast-iron voussoirs, an arch equal and even exceeding either of these spans may be executed with safety.

In the construction of an arch upon this principle, it is proposed to have a raised piece cast on the side of each voussoir, fitting into a corresponding hollow in the one adjoining. By this means the whole becomes more firmly joined together, forming, as it were, a series of joggles throughout the whole structure, and entirely preventing any tendency of the arch to rise at the haunches, or of any of the voussoirs to slide. This is a very important advantage, and one which, in an iron arch, can be easily obtained with little or no additional expense.

Fig. 1.—Transverse Section of Voussoir.

Fig. 2.—Transverse Section of Arch.

The form of the voussoirs may either be made similar to those in stone bridges, with the addition of these projections and hollows (see figs. 1, and 2), or, where additional strength is required, they may be executed according to fig. 3.

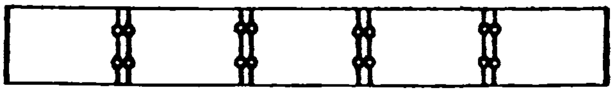


Fig. 3.—Transverse Section of Arch.

On account of the voussoirs being all firmly fixed to each other by means of the joggles already mentioned, it would not, on all occasions, be necessary that they be placed close to each other at the ends, but kept a little separate, as shown in fig. 4. By this means, while the arch could still be made sufficiently strong, a considerable saving of material would be effected.

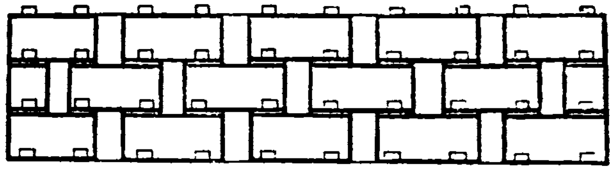


Fig. 4.—Plan of part of Arch.

As to the thickness of metal required for small and medium spans, the average may be from ½ to ¾-inch, and for large spans one inch would be sufficient for the average, care being taken that the ends of the voussoirs be made thicker than the sides. In order still further to strengthen the ends without requiring additional metal, the sides may be made slightly open.

In places where stone cannot be easily obtained, bridges could be constructed on this principle at a very moderate cost, while they at the same time would be both substantial and durable. The spandrils and abutments may be constructed of such materials as could be most readily obtained, and which was considered suitable; as such bridges admit of being finished similar to a stone one or otherwise, acording to the taste of the projectors and resources of the locality.

REVIEWS.

An Elementary Course of Geology, Mineralogy, and Physical Geography. By David T. Ansted, M.A. F.R.S. London: Van Voorst, 1850.

We are precluded from writing an article on Professor Ansted's new book, because on former occasions, prompted by him, we have gone over the whole subject of geology and engineering; and because he has so fully carried it out as to leave us no ground for cavil, and only the opportunity of expressing strongly our approval of the volume now before us. So far from being a mere reproduction of the Professor's former works, this is a complete manual of the several allied sciences, most carefully treated according to the last discoveries in the important domain of philosophy to which these newest offspring of science belong.

What was in the first instance a few pages has now become a regular section on practical geology and its application in engineering, and it has ceased to be a matter of question whether geology is an essential part of professional education.

As a trifling illustration of the intimate connection of geological facts with our pursuits, we give the following:—

"The whole quantity of water in the chalk of England north of the Wealden anticlinal must be enormously great, but is hardly calculable. At the very lowest conceivable estimate, considering the total area as 6000 square miles, the mean thickness only 300 feet, and only one-third of this fully saturated to the extent of one-fourth its volume, it would amount to twenty-five millions of millions of gallons; while the annual supply from rain to the extent of six inches of water absorbed per annum over an area of 2000 square miles, would amount to nearly 175,000,000,000, or more than $\frac{1}{150}$th part of the whole quantity of water contained. If the population of the chalk districts, including the whole area covered by London clay and gravel, be taken at 4,000,000 of individuals, and fifty gallons per day be allowed for each, a very large and sufficient quantity for all possible sanitary purposes, there will thus be needed only about 72,000,000,000 gallons per annum for this purpose, or not much more than a third of the estimated annual supply from rain, and only $\frac{1}{350}$th part of the quantity contained in the rock. It is unnecessary to state that only a part of this is directly available; but there must be a very large proportion that could be pumped out, although it may be a very different question as to how far this mode of obtaining water on a large scale is economical, or in other respects advisable.

"In the above estimate the quantities throughout are reduced to the very lowest that can be imagined, to show that the supply of water must be much greater than any demand that can arise. In point of fact, the proportion of rain entering the rock is more likely to be 12 inches than 6; the mean thickness of chalk might fairly have been taken at 600 feet instead of 300; and the quantity of water contained, instead of being taken at one-twelfth, may have been considered one-sixth of the bulk. Estimated in this way, the quantity of water in the chalk would be 100,000,000,000,000 gallons, and the annual supply 350,000,000,000. In addition to the quantity of rain, a large supply of water must enter some parts of the chalk from mere absorption from the atmosphere.

"The quality of water is unquestionably affected by the rocks through which it passes: although in this respect it is not always safe to conclude what the result will be without actnal investigation. Thus water obtained from surface-deposits is almost sure to contain in solution some of those organic substances which in cultivated land must always abound, and which are always carried down to some little distance by the descending supply of rain; water from irony rocks, whether sand or otherwise, being generally chalybeate, and that from calcareous rocks holding carbonate and other salts of lime in solution. But when we examine the analyses of different rocks, as given in previous tables, there will be found also a number of other ingredients, as salts of soda, potash, magnesia, and other substances, and these will also be taken up, while the very action of water and the decompositions otherwise going on, produce sulphuric acid, and thus again act upon the containing rock, or alter combinations already in solution in the water. Thus it results, that in wells, however the water is obtained, there will be a certain proportion of saline and other ingredients, although the actual quantity may be less in amount and different in character in the case of deep and shallow wells in the same locality.

"It appears from a paper by Professor Brande, in the 'Quarterly Journal of the Chemical Society,' vol. ii. p. 345, that a well was sunk 426 feet deep, into 202 feet of chalk to supply the Mint. This well was completed 1st of January, 1847. The water rises to within 80 feet of the surface, and about 45,000 gallons per day are obtained; the level being then reduced by this amount of exhaustion to about 100 feet from the surface.

"Before the water was obtained from the chalk it yielded 44 grains of dry saline matter in the gallon of water. Since the well was finished the quantity is only 37·8 grains:—SG at 55°=1000·70."

On Mining there is very copious instruction, and from this part we take another illustration.

"Another fact to be considered by the practical miner, is that of the singularly frequent disturbances that have affected the beds of coal and the strata associated with them, and the remarkable complication of the *faults* that characterise many coal-fields. It must not be supposed that the effect of these disturbances is either uniformly advantageous or always disadvantageousto the immediate interests of the miner; but there cannot be the slightest doubt that we are indebted to such disturbances for frequent repetitions of the same bed of coal at the surface, when without them it would be so far covered up by newer deposits as to be utterly unattainable. If occasionally the miner, in prosecuting his labours, or the mine-owner in following what he considers a valuable seam of coal, is suddenly stopped by coming in contact with a fault, and finds the coal shifted several yards above or below, or even completely lost, he must not forget that it is perhaps owing to these very shifts that the outcrop has taken place at all in his neighbourhood, and that the coal is workable in the district in which he is interested.

"But there is another important advantage derived from the existence of these numerous faults in coal strata, namely, that they intersect large fields of coal in all directions, and by the clayey contents which fill up the cracks accompanying faults, become cofferdams, which prevent the body of water accumulated in one field from flowing into any opening which might be made in it from another. This separation of the coal-field into small areas, is also important in case of fire, for in this way the combustion is prevented from spreading widely, and destroying, as it would otherwise do, the whole of the seam ignited.

"An instance of the advantage resulting from the presence of a great line of fault, occurred in the year 1825, at Gosforth, near Newcastle, where a shaft was dug on the wet side of the great ninety-fathom dyke, which there intercepts the coal-field. The workings were immediately inundated with water, and it was found necessary to abandon them. Another shaft, however, was sunk on the other side of the dyke only a few yards from the former, and in this they descended nearly two hundred fathoms without any impediment from the water."

A Catechism of the Steam-Engine. By JOHN BOURNE, C.E. Third Edition. London: Longman, 1850.

We are glad to see the third edition of this work. We noticed it favourably on its first appearance, and it has since received several improvements.

Practical Ventilation, as applied to Public, Domestic, and Agricultural Structures. By ROBERT SCOTT BURN, Engineer. London and Edinburgh: Blackwood, 1850.

We had intended to notice this work at some length, for the subject is of practical importance, but unfortunately we are compelled to postpone this design until next month. In the meantime we may observe, that though the author has not announced any new doctrine, he appears to have collected very judiciously the opinions of Rumford, Tredgold, Arnott, Reid, and others, and to have put them in a shape suitable for the practical man.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

INSTITUTION OF CIVIL ENGINEERS.

April 30.—WILLIAM CUBITT, Esq , President, in the Chair.

The paper read was "*On the Absorbent Power of Chalk, and its Water Contents, under different Geological conditions.*" By Professor D. T. ANSTED.

After explaining the nature and extent of the chalk rock of England, both geologically and topographically, and briefly describing its chief physical peculiarities, the author proceeded to detail the results of some experiments made for the purpose of ascertaining the positive and relative absorbent powers of different kinds of chalk, when exposed to moisture under various circumstances.

The specimens experimented on were small cubes, each weighing from three to four ounces, taken from different districts and geological positions, in the upper, middle, and lower beds of the chalk.

From these experiments, it appeared, that the upper chalk, when it was to all appearance perfectly dry, contained about one-third part of a pint of water in each cube foot, which was never parted with under any conditions of dryness of the atmosphere; that in the case of an exposed surface of the rock, the absorption from a moist atmosphere would be unimportant, although when water was presented to it in a liquid form, the upper chalk was found capable of receiving into its mass a quantity of water amounting to more than two gallons for every cube foot of rock, beyond the quantity usually contained in apparently dry chalk, under ordinary exposure.

A specimen of the middle chalk, when thoroughly air-dried by six months' exposure, was found to contain about 23 parts water in 1000 parts; three-fourths of which water were readily given off by subsequent exposure to a perfectly dry atmosphere, very little more than the original quantity being re-absorbed on exposure to a saturated atmosphere; showing that the absorbent power, in this respect, was even less than in the case of the upper chalk. The quantity of water contained in a cube foot of saturated middle chalk was rather more than two gallons.

A specimen of the lower chalk was found to contain more than 10 parts of water in 1,000 parts, about three-fourths of which were rapidly parted with, on exposure to a perfectly dry atmosphere; but the rest, amounting to more than the quantity of water contained in the upper chalk, in its ordinary state, was not parted with by any exposure, short of a vacuum. On subsequent exposure to a saturated atmosphere, more than 15½ parts of water in 1,000 parts, were absorbed, and when the specimen was saturated, its water contents exceeded 2½ gallons per cubic foot.

It was stated, that the upper chalk might generally be regarded as the *conducting*, and the lower chalk as the *containing*, part of the formation, so far as water was concerned; and that chalk must be regarded as a rock, which everywhere admitted the percolation of water, receiving into itself, and conveying to its lower beds, the water that fell on, or was brought to, its surface. This readily explained the uniformly dry appearance it presented, and the absence of any streams, arising from mere surface drainage, where extensive exposure of the rock itself occurred. It also appeared that particular bands of rock contained much more water than others, some, indeed, being apparently, though not really, dry, when below the surface of permanent wetness; while others gave off water readily, and to a large extent.

The probable effect of rain-fall upon the surface of the exposed chalk was then considered, and it was estimated, that at least 18 inches descended annually to what was called the surface of permanent wetness, maintaining a general and rude parallelism with the surface of the ground; but when the chalk rock was permanently covered with impermeable soils, as in the London basin, the position of the surface of permanent wetness was liable to extreme variation, and to be most seriously affected, as lateral percolation was then the only source of wetness.

On the other hand, it was thought, that a large portion of chalk rock existed in a state of uniform and permanent wetness, and that wherever the gault extended, underlying the chalk and keeping up the water, there must be, at and below a certain depth from the surface, a supply of water to the extent of 180 millions of gallons for each square mile one yard in thickness; and that the surface of permanent wetness, dependent chiefly on the present rain-fall, was so far above this lower surface of saturation, as to ensure a supply at least equal to one-half of the rain falling on the immediately surrounding district.

May 7.—The paper read was "*On the Application of Water-Pressure, as a Motive Power, for working Cranes and other kinds of Machinery.*" By Mr. W. G. Armstrong, F.R.S., Assoc. Inst. C.E.

The object of the paper was to direct attention to the advantages of a more extended application of hydraulic pressure, as a motive power, and to point out the means of attaining this desirable end; illustrating the arguments by descriptions and drawings of the engines on this principle, already erected, since the year 1845, when the author first designed a crane, to be worked by the pressure of water from the street water-pipes, at Newcastle-upon-Tyne.

The principle of these engines, as applied to cranes, was described to be very simple. In order to lift a weight, the water, under a pressure of about 100 feet head, or more, being admitted through a slide valve into a cylinder, exerted a force on a piston, whose rod was connected with the hoisting-chain, so arranged by passing over several pulleys, as to increase its length of travel to the requisite duty to be performed; the piston receding from the pressure therefore raised the weight to the height required. The lowering of the weight was accomplished by a reverse action, and the crane was turned in either direction by a similar action of a smaller cylinder, whose piston rod was connected with a rack, working into a circle of teeth, fixed to the base of the moveable frame of the crane.

The action of these machines was described to be very smooth and steady, ingenious appliances being adopted for obviating the shock that would otherwise be caused by the sudden closing of the slide valves, and all the different operations being under the perfect control of a few regulating handles. In cases of a great diversity of power being required, separate cylinders were used, so arranged, as that their action could be combined, according to the force required. The speed of working had no other limit than the size of the supply pipe.

Allusion was made to the advantage of employing hydraulic pressure in mercantile docks, for hoisting heavy weights, for whipping light goods out of ships, and for opening and shutting dock gates, swing bridges, and sluices. Its facility of transmission, its safety, and constant readiness for use, rendered it peculiarly suitable for these purposes. It would generally be preferable in such cases to employ steam power to force the water, rather than to be dependent upon town water-works; and a tank upon a tower, or upon an eminence, would form a convenient magazine of power, enabling the engine to act continuously with an uniform load. Large air-vessels had also been successfully employed, instead of an elevated tank.

Hydraulic pressure might, also, in many cases, be advantageously employed for purposes requiring continuous rotation. There were many natural situations where mountain streams might be arrested, or surface-water be impounded on elevated ground, and be conveyed by a pipe into a neighbouring valley, where great mechanical efficiency might be derive [illegible] small supply of water, by the use of water-pressure engines. In mining operations, also, the danger and inconvenience of underground steam-engines might be obviated, by substituting water-pressure engines, conveying the water down the shaft in pipes, and returning it to the surface, by the action of the pumping engine aboveground. In such cases the water was merely the vehicle for transmitting power into the mine.

A water-pressure engine had been lately very successfully applied by the author, in South Hetton Colliery, for the traction of wagons upon an underground railway. Similar engines had also been erected in the lead mines at Allenheads, for lifting ore, and other purposes. Reservoirs were there formed upon the neighbouring hills, and pipes were carried into the mines to supply the engines, the expended water flowing out by a level. Other engines of the same description were also in course of erection, for surface operations, at the same place, such as crushing ore, and raising minerals from the shafts.

In their general character, these engines were similar to reciprocating steam-engines. The slide valves were balanced by equal pressures in opposite directions, and were constructed to open very spacious water passages. The liability to concussion, on the closing of the eduction port, was obviated by the application of relief valves, which were lifted by the compressive action of the piston, causing it to act for an instant, as a pump, in forcing back the opposing water into the supply pipe. In cases where the engines had been applied to hauling, or winding, four cylinders placed diagonally in pairs, had been used. In other cases, two cylinders had been applied, the uniformity in the motion of the column being maintained by a loaded plunger. The winding engines were reversed by a slot link apparatus, similar to that of a locomotive engine, and which was worked by the pressure of the water, acting under the control of a valve. The regulating and reversing valves were each placed at the mouth of the shaft, at a distance from the engine, the operation of which could thus be directed with great accuracy and safety.

The drawings which accompanied the paper gave representations of an Hydraulic Crane, for shipping coals at Glasgow; Hydraulic Platform Cranes, at the railway station, Newcastle-upon-Tyne; Hydraulic Hoisting Machines, at the warehouses of the Albert Docks, Liverpool; a Water-pressure Engine, for a crushing-mill at Allenheads; a similar engine used at the same place, for winding; and numerous details of all these machines.

May 14.—The paper read was "*On the Construction of the Permanent Way of Railways; with an Account of the wrought iron Permanent Way, laid down on the Main Line of the North Midland Railway.* By Mr. W. H. Barlow, M. Inst. C.E.

The author commenced by entering into the question of the maintenance and renewal of the ordinary railways, analysing very minutely the expenses under the different heads, and showing to what causes the derangement of the line might be attributed. The cost of maintenance was stated to be dependent on two causes, the effect of weather, &c., and the disturbance produced by traffic; and from a summary of the expenditure of the different lines belonging to the Midland company, it appeared that the former amounted to 20*l.* or 30*l.* per mile per annum, and the latter varied from 2*d.* to 2·7*d.* per train per mile. After a line was consolidated, by far the greater part of this expenditure was due to the derangement caused by the passage of the trains, which first produced an uneven joint, then loosened the joint key, and then disturbed the sleeper, so that at length the whole of the permanent way generally was degraded.—With regard to renewal, it had been estimated by the officers of the London and North-Western Railway, that on their line the rails would last twenty years, and the sleepers, if 'creosoted,' twenty years, but if unprepared only twelve years; now as the duration of service of the rails was dependant on the amount of the traffic, and that of the sleepers on the weather, it was quite evident, that on lines having less traffic than the London and North-Western, the proportionate expense of renewing the sleepers would be much greater, and would increase as the amount of traffic diminished.

In endeavouring to seek a remedy for this, the author conceived, that, by increasing the dimensions of the bridge rail, sufficient width might be obtained for it to take its own bearing in the ballast, without the use of either transverse sleeper, or longitudinal supports; and, moreover, that such a construction wouuld possess great strength, be very durable, and be capable of being renewed at a moderate expense. He therefore proposed a bridge rail, 13 inches in width, 5¾ inches in depth, and weighing 126 lb. per lineal yard. There was some difficulty at first in getting it manufactured, but Messrs. Bolckow and Vaughan, of Middlesborough-on-Tees, had overcome all the practical difficulties, and now produced rails of the required size, with hard metal in the upper portion, and ductile metal in the lower, by which both durability and strength were insured. The joint was made by either a cast or wrought iron chair, or saddle, which received the ends of the rails, and into which they were keyed with wooden keys. The gauge was preserved by means of a tie-bar, fitted and keyed into sockets on the chairs.

An experimental length of road on this construction had been laid down on the main line of the North Midland Railway, the cost of which was 3323*l.* per mile; but it was thought, that in future this might be reduced to 2487*l.* per mile, by reducing the weight of the rails to 100 lb. per yard, and the chairs in proportion, as it was found by experiment, that these rails were greatly in excess of strength, being as much as three times stronger than the ordinary double-headed rail. A mile of road had also been laid upon the same line, with cast-iron sleepers adapted to the ordinary rail, as introduced by Mr. P. W. Barlow, M. Inst. C. E.; and another mile had been laid with these cast-iron sleepers at the joints only, but having intermediate sleepers of timber. The motion of the trains over their several experimental lengths was firm and steady, there being no perceptible difference between the two latter descriptions.

May 21.—The paper read was "*On Printing Machines; especially those used in the printing of the 'Times' newspaper.* By Mr. Edward Cowper.

The object of this paper was principally to describe the machinery, which had been in use, at various times, for printing the 'Times' newspaper, other machines being only referred to, as assisting to illustrate the subject.

For this purpose a brief review of the progress of printing machinery was given; from which it appeared, that the first patent was obtained by Nicholson, in 1790, who then proposed placing both the types and the paper upon cylinders, and distributing and applying the ink also by means of cylinders; another plan was to place common type upon a table, which was passed under a paper cylinder. In 1813, Donkin and Bacon proposed placing the type upon a prism, and introduced "composition" rollers. In 1816, Cowper made a machine to print from curved stereotype plates; and in 1818, one to print books from ordinary type; he also introduced the system of inking now in common use. In 1814, Kœnig made the first working machine, and erected two of these at the 'Times' office, which produced eighteen hundred impressions per hour, and continued to do so until 1827, when they were superseded by Applegath and Cowper's four-cylinder machine, producing five thousand impressions per hour.

These machines, which were stated to be still in use at the 'Times' office, consisted of a table moved backwards and forwards under four iron cylinders (called the paper cylinders), about nine inches in diameter, which were covered with cloth, and round which the sheets of paper were held between tapes. The forme was fixed on one part of the table, the inking rollers lying on another part, on which they distributed the ink: some of these rollers were placed in a diagonal position on the table, so that, as it moved backwards and forwards, they had a motion in the direction of their length, called the "end-motion," which, combined with the rotatory motion, caused the ink to be more effectually distributed. The ink was held in a reservoir, or trough, formed of an iron roller, called the ductor, against which the edge if an iron plate rested, and, by its pressure, regulated the quantity of ink given out. The ink was conveyed from the ductor-roller to the table, by means of an elastic roller vibrating between them. The feeding was performed by four "layers-on," who laid the sheets of paper on the feeding boards, whence they entered the machine between three pairs of tapes, by which they were conveyed round the cylinders, and thence to the spot where the "takers-off" stood, into whose hands the sheets fell, as the tapes separated.

In May, 1848, the last great improvement was introduced, when Mr. Applegath erected at the "Times" office a vertical machine, which was stated to produce the enormous number of 10,000 impressions per hour. This machine consisted of a vertical cylinder, about sixty-five inches in diameter, on which the type was fixed, surrounded by eight other cylinders, each about thirteen inches in diameter, covered with cloth, and round which the sheets of paper were conveyed by means of tapes; each paper cylinder being furnished with a feeding apparatus, having one boy to lay them on and another to take them off. The inking rollers were also placed in a vertical position, against the large cylinder, upon a portion of the surface of which they distributed the ink. The ink was held in a vertical reservoir, formed of a ductor-roller, against which rested two "straight edges," connected at the back, so as to prevent the ink from running out: it was conveyed from the ductor-roller by one of the inking-rollers, against which it was occasionally pushed.

The type used was of the ordinary kind, and the forme was placed upon a portion of the large cylinder, being fixed to it in a very plain but ingenious manner: a slab of iron was curved on its under side, so as to fit the large cylinder, whilst its upper surface was filed into facets, or flat parts, corresponding in width and number to the width and number of the columns of the newspaper. Between each column there was a strip of steel, with a thin edge, to print the "rule"—the body of it being wedge-shaped, so as to fill up the angular space left between the columns of the type, and to press the type together sideways, or in the direction of the lines; the type was pressed together in the other direction by means of screws, and was therefore firmly held together. The surface of the type thus formed a portion of a polygon; and the regularity of the impression was obtained by pasting slips of paper on the paper cylinders.

The operation of the machine was very simple: the "layer-on" drew forward a sheet of paper on the feeding-board, until its edge was under a roller, furnished with tapes, which dropped down and drew the sheet forward and downward, into a vertical position, when other rollers and tapes carried it round the paper cylinder, when it met the type, which had been inked by passing in contact with the inking-rollers; the sheet then continued its progress until it reached the "taker-off."

Some interesting statistics, relative to the printing of the 'Times,' were mentioned, from which it appeared, that on the 7th of May, 1850, the 'Times' and 'Supplement' contained 72 columns, or 17,500 lines, made up of upwards of a million pieces of type, of which matter about two-fifths were written, composed, and corrected after 7 o'clock in the evening. The 'Supplement' was sent to press at 7·50, P.M., the first forme of the paper at 4·15, A.M., and the second forme at 4·45, A.M.; on this occasion, 7,000 papers were published before 6.15, A.M., 21,000 papers before 7.30, A.M., and 34,000 before 8.45, A.M., or in about four hours. The greatest number of copies ever printed in one day was 54,000, and the greatest quantity of printing in one day's publication was on the 1st of March, 1848, when the paper used weighed 7 tons, the weight usually required being 4½ tons; the surface to be printed every night, including the 'Supplement,' was 30 acres; the weight of the fount of type in constant use was 7 tons, and 110 compositors and 25 pressmen were constantly employed. The whole of the printing at the 'Times' office was actually performed by three of Applegath and Cowper's four-cylinder machines, and two of Applegath's new vertical cylinder machines.

The President afterwards briefly addressed the meeting, congratulating the members on the continued success and prosperity of the Institution, and expressing a hope that during the recess, original communications would be prepared for the next session, so that it might, at least, equal in interest that which had just concluded.—The meeting was then adjourned until the second Tuesday in November.

It was moved, seconded, and carried unanimously, that the cordial thanks of the Institution be offered to the President, for the unwearied attention he had paid to the interests of the Institution, and for the urbanity he had at all times displayed in the chair.

THE PRESIDENT'S CONVERSAZIONE.

On Tuesday evening, the 28th, Mr. Cubitt, President of the Institution of Civil Engineers, gave a conversazione at the House of the Institution, in George-street, the arrangements for which were very ably and tastefully made by Mr. Charles Manby, the Secretary, by whose exertions these annual celebrations have attained a high reputation. The Institution was for the nonce converted into a palatial building, decorated with paintings and works of art, among which were some *chef d'œuvres* of Landseer. In the reception room was his 'Diogenes,' which was a great object of attraction. Some fine electro-bronzes, by Elkington, excited great interest; and, in particular, a statue of Antinous. In the corridor was the fine specimen of bookbinding by Gruel, of Paris.

The model-room was crowded with models and with spectators; and although from the want of any great work in progress there was no striking novelty, the collection was by no means deficient in interest. Floating about the rooms were small balloons, to show the plan for distributing messages in the Arctic regions, in the attempt to communicate with Sir John Franklin. Mr. Cotton's sovereign weighing-machine was worked throughout the evening. Appold's register hygrometer is for keeping the atmosphere of a house at one regular moisture. Another contrivance of that gentleman was a thermometric balance, to open or shut the damper of a stove, on a variation in the temperature of 1° Fahrenheit. The model of the Great Grimsby cofferdam was shown. A very ingenious machine was a rotary card press, an American invention, capable of printing by hand 2,500 cards per hour. There were gutta percha inventions, Dujardin's electric telegraph, the screw pile, model of Gatton House, the disc-engine, Whishaw's telephone and telekouphonon, Le Molt's electric battery, Soyer's magic stove, and many things too numerous to remember.

Among the company were the Marquis of Salisbury; Earls Lovelace, Harrowby, Rosse, Powis; Lords Wharncliffe, Overstone, Ebrington, De Mauley; Baron de Goldsmid; Sirs Robert Peel, G. Staunton, D. Norreys, P. Laurie, B. Brodie, Howard Douglas, C. E. Pasley, James Duke, H. Ellis, Isaac Morley, J. Hamilton, H. T. De la Beche, W. S. Harris, C. Malcolm, R. Westmacott, W. Symonds, E. Ryan, C. Fellowes, G. Back; Messrs. H. T. Hope, M.P., Rowland Hill, Mackinnon, M.P., Locke, M.P., Cubitt, M.P., Lacy, M.P., Jas. Heywood, M.P., Masterman, M.P., C. Dickens, W. F. A. Delane.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

On Friday, the 3rd ult., Earl de Grey, the President, gave a conversazione to the Fellows, which was numerously attended by them, as well by a large circle of men distinguished in every career of life. Few architectural works were exhibited, but many portfolios of drawings.

We noticed among the company, Lord Lansdowne; Lord Granville; Lord Ashley; Lady Cooper and Lady Mary Viner, daughters of Earl de Grey; Mr. H. T. Hope, M.P.; Beresford Hope, M.P.; Mons. Dusillion; Sir Robert Peel; Lady Peel and daughter; Sir Alexander Johnstone; Sir Charles Pasley; Colonel Sykes; Sir R. Westmacott, R.A.; C. Landseer, R.A.; Mr. Knight, R.A.; J. Martin; Sir W. Newton, R.A.; Sir — Ross, R.A.; Mr. Haghe; Mr. Robert Stephenson, M.P.; Mr. Brunel, C.E.; Mr. Cubitt, C.E.; Mr. C. Manby; Mr. Barry; Mr. Tite; Mr. Donaldson; Mr. Fergusson; Mr. Donthon; Mr. Bailey; Mr. Kendall; Mr. Fowler; Mr. Roberts; Mr. Angell; Mr. Bellamy; Mr. Smirke; Mr. T. Wyatt; Mr. Brandon; and Mr. Digby Wyatt.

SOCIETY OF ARTS, LONDON.

April 17.—Mr. Antoine Claudet read a paper "*On the Properties of the Diamond for Cutting Glass, with descriptions of machines invented by him, in which the Diamond is made to perform perfectly what by manual labour had before been very imperfectly done.*"

The author commenced his paper by a very interesting description of the nature of the diamond, of the form of its natural crystal, and of the mode in which it cuts glass,—quoting a paper on the subject by the late Dr. Wollaston, in the 'Philosophical Transactions' for 1816, as well as by a history of the use of glass in windows from the earliest times, when it was used only in ecclesiastical buildings of great splendour, down to its present universal application. He has also, in order the more thoroughly to make apparent the advantage of the use of the diamond, described minutely the very tedious and imperfect methods by which, before its introduction, glass was cut and shaped. The property in question was first found out about the time of Francis I. of France, the well-known anecdote of whom is quoted; and the different tools used from that time to the present for its manual application are detailed and commented on, many of them being exhibited by the author. The first of these was a mere handle, having the diamond firmly inserted into the lower end. But the handle being round, and the diamond, from the form of its crystal, requiring one unvarying direction to be preserved in order to produce a cut, this was found so imperfect that a step was taken by making the end of the handle flat, to preserve the parallelism against the rule. This, from the shape of the bottom in which the stone was set, was called the "plough diamond." In 1814, Shaw, of London, made a great improvement, and brought the instrument to the shape in which it is still used, by making the metallic setting of the diamond moveable on a ferrule at the bottom of the handle, thus putting it out of the power of any deviation of the hand from the proper position to affect the direction of the stone. This, perfect as it may seem, is still difficult to use, and requires long practice for expert performance. The two tests by which the workman knows when his tool is "making a cut" are, the sound and the feel. A modification of the last-named tool, by the brother of its inventor, was formerly used for those who have but little practice; but it was very little used, and the one shown to the meeting by Mr. Claudet was curious, from being, perhaps, the only one now in existence. A contrivance for cutting circular plates was shown in action.

The cause of the invention of the machines, the description of which was the principal object of the paper, was the increased use of glass shades for covering ornaments, the cutting of which, so that they should stand perfectly firm and with an even base, was a most tedious and imperfect operation when done by hand. The manufacture of these shades, which, under the name of "cylinders de verre," had long been carried on in France, was first undertaken in England, at the instance of Mr. Claudet, by Mr. Lucas Chance of Birmingham, who, in the true spirit of enlightened enterprise, notwithstanding the vexatious pressure of the excise laws, now repealed, embarked largely in the manufacture, getting workmen from France, for making both shades and the sheet glass, which had there been for some time made from cylinders. It was now, however, found that some method of cutting the bottom of the shades and cylinders must be adopted surer and less expensive than the manual method, and Mr. Cleudet was driven by this necessity to invent his machine.

The principle of the machine, expressed in the fewest words, is this: The shade is firmly fixed between an internal support and a transverse bar above it, in a perfectly upright position, above a horizontal, level, and smooth table, its bottom being a few inches above the table. Upon the table travels a small but heavily-weighted base moving on castors, having springing from it two upright pillars, one holding the diamond, and the other forming a support opposite to it. The pillar holding the diamond is fixed, but the other is moveable, being by a spring kept close to it. The height of the whole is such that when on the table, the diamond is about an inch above the bottom of the shade. The diamond being introduced inside the shade as it hangs suspended, the pressure of the spring is sufficient to cause it to cut, and it has only to be moved round the shade, the horizontality of the table causing the cut to be perfectly level. This machine was exhibited, and the bottoms of shades cut by it, before the meeting. The shape of the shade, whether oval, round, or square, is unimportant in the use of this machine, but Mr. Claudet has contrived another for the cutting of round shades only, in which the shade is laid horizontally,—an elegant system of adjustments being provided, by which shades of any diameter can be cut by the workman with little risk of error. This machine was also shown in action.

May 1.—G. Moffatt, Esq., M.P., in the Chair.

"*Abstract of a Paper on the Causes and Preventives of Mildew in Paper and Parchments; with an account of Experiments made on the saturation of growing Wood with Antiseptic Chemical Solutions.*"* By Alfred Gyde, M.R.C.S.E.

Owing to the imperfections formerly existing in the microscope, little was known of the real nature of the class of plants called *fungi* until within the last few years; but since the improvements in that instrument, the subject of the development, growth, and offices of the fungi has received much attention. They compose, with the algæ and lichens, the class of *Thallogens* (Lindley), the algæ existing in water, the other two in air only. A fungus is a cellular flowerless plant, fructifying solely by spores, by which it is propagated, and the methods of attachment of which are singularly various and beautiful. The fungi differ from the lichens and algæ in deriving their nourishment from the substances on which they grow, instead of from the media in which they live. They contain a larger quantity of nitrogen in their constitution than vegetables in general do, and the substance called "fungine" has a near resemblance to animal matter. Their spores are inconceivably numerous and minute, and are diffused very widely, developing themselves wherever they find organic matter in a fit state. The principal conditions required for their growth are moisture, heat, and the presence of oxygen and of electricity. No decomposition or development of fungi takes place in dry organic matter; a fact illustrated by the high state of preservation in which timber has been found after the lapse of centuries, as well as by the condition of mummy cases, bandages, &c., kept dry in the hot climate of Egypt. Decay will not take place in a temperature below that of the freezing point of water, nor without oxygen, by excluding which—as contained in the air—meat and vegetables may be kept fresh and sweet for many years.

The process which takes place when moist vegetable substances are exposed to oxygen is one of slow combustion, and has been called by Liebig "*Eremacausis*," the oxygen uniting with the wood and liberating a volume equal to itself of carbonic acid; another portion combining with the hydrogen of the wood to form water. Decomposition takes place on contact with a body already undergoing the same change, in the same manner that yeast causes fermentation. Animal matter enters into combination with oxygen in precisely the same way with vegetable matter; but as, in addition to carbon and hydrogen, it contains nitrogen, the products of the *Eremacausis* are more numerous—carbonate and nitrate of ammonia, carburetted and sulphuretted hydrogen, and water: and these ammoniacal salts greatly favour the growth of fungi. Now, paper consists essentially of woody fibre forming its substance, with animal matter, as size, on its surface.

The first microscopic symptom of decay in paper is irregularity of surface, with slight change of colour, indicating the commencement of the processes just noticed; during which, in addition to carbonic acid, certain organic acids are formed—as cremic and ulmic acid, which, if the paper have been stained by a colouring matter, will form spots of red on the surface. Spots of the same kind are similarly formed on leather coloured during its manufacture. Provided that fungi have not taken root, the colour can be restored by ammonia or any alkali. The same process of decay goes on in parchment as in paper; only with more rapidity, from the presence of nitrogen in its composition. When this decay has begun to take place, fungi are produced—the most common species being *Penicillum glaucum;* they insinuate themselves between the fibre, causing a freer admission of air, and consequently hastening the decay.

The substances most successfully used as preventives of decay, are the salts of mercury, copper, and zinc. Bichloride of mercury (corrosive sublimate) is the material employed in the kyanisation of timber, the probable mode of action being its combination with the albumen of the wood, to form an insoluble compound insusceptible of spontaneous decomposition, and therefore incapable of exciting fermentation. The antiseptic power of corrosive sublimate may be easily tested by mixing a little of it with flour paste; the decay of, and appearance of fungi on which are quite prevented by it. Next to corrosive sublimate in antiseptic value stand the salts of copper and zinc. Chloride of zinc has been patented by Sir W. Burnett for the preservation of wood, sail-cloth, &c., and appears to succeed admirably. For use in the preservation of paper, the sulphate of zinc is better than the chloride, which is to a certain extent deliquescent.

A series of experiments were made by the author in the summer of 1840 on the use of metallic and other solutions for the preservation of wood. A deep saw-cut was made all round the circumference of the growing trees near their base, into which the solutions were introduced by forming a basin of clay beneath the cut; thus the solution took the place of the ascending sap, and in periods of time, varying from one to three days, was found to have impregnated even the topmost leaves of trees fifty feet high. The trees were chiefly beech and larch. After impregnation they were felled, and specimens about five feet long by two inches square cut out, and packed in decaying sawdust in a warm damp cellar, where they were left for seven years. The details of the experiment are given in a table, by which the following general results are made to appear:—The wood saturated with sulphate of copper, in the proportion of one pound to one gallon of water, or with acetate of copper, one pound to one pint of vinegar and one gallon of water, were found in perfect preservation, clean, dry, and free from fungus; the remainder, which were saturated with nitrate of soda, prussiate of potash, pyrolignite of iron, sulphate of iron, common salt, and creosote, presented much decay, and a large growth of fungi.

The results obtained from solutions of corrosive sublimate—one-eighteenth of a pound to a gallon of water (Kyan's proportion) varied in an anomalous manner.

"*On the Patent Safety Steering-Wheel of* Captain Fayrer, R.N., *and* Lieut. Robinson, R.N."

Serious accidents occur to the helmsmen in large vessels from the little power which they have to resist the sudden shocks caused by the sea

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* This Paper was rewarded in 1848 with the Society's Gold Isis Medal.

striking the rudder, by which the helm is often taken out of their hands, and they are either thrown overboard or much hurt. A constant experience of such accidents, during his command of the three large steamers, *President*, *Liverpool*, and *Forth*, and of the *Lady Flora*, Indiaman, led Captain Fayrer to consider some method of preventing them, and, at last, to this invention.

It consists in the application to the steering-wheel of a friction-band similar to that used in cranes, which passes round a projecting circumference inside the wheel, and is brought down to a pedal on the deck, by pressure on which any amount of friction can be put on the wheel. It is not desirable that the helm should ever be at a 'dead lock,' without the power of yielding a little to the shock of a very heavy sea, as that would endanger the carrying away of the rudder; an adjusting screw is therefore provided, by which the amount of *ultimate* friction that can be put on the wheel is regulated, and not left in the power of the steersman. A great advantage of this invention is the power which it gives of fixing the rudders of vessels lying in a tide-way or harbour, and thereby preventing the continual wear on the pintles of the rudder, and, in time, the loosening of the stern framing of the vessel. Letters testifying to the merit of the safety steering-wheel, from eminent ship-builders and naval engineers, were read. It is being applied to the large steamers *Asia* and *Africa*, now being built at Greenock, for the North American mail service. The communication was illustrated by drawings, and by a very well-executed model.

BRUSSELS ACADEMY OF SCIENCES.

Prizes are offered for the best papers on the following subjects:—

An elaborate examination of the state of our present knowledge respecting rain, and of the principal causes which serve to modify this phenomena. —Gold medal of the value of 600 francs.

To be sent in before September 20th, 1850.

To give a full account of the different researches which have been undertaken, for the purpose of preserving materials employed for building purposes, such as stones of different kinds, marble, brick, cement, stuccoes, &c., unalterable by external agents. To point out those processes which appear to have been attended with success, and to enter into a discussion of the probable causes of that success. Lastly, to point out some methods of preservation superior to those already known, which may be employed for the materials above mentioned, those methods being, on suitable theory, on experiments duly authenticated, and in accordance with that theory.—This prize, to be awarded by the Government, will consist of 1,500 francs (60*l.*) and a gold medal, of the value of 600 francs (24*l.*)

To be sent in before September 20th, 1851.

UNITED STATES NAVAL DRY DOCKS.

At the present time the United States Government have in progress four different dry docks capable of docking the largest vessel afloat. From their great size and the many improvements that have been introduced, a correspondent of the *Franklin Journal* says that they are far superior to any at present in use in Europe. Of the four now building one is at Philadelphia, and is known as the floating *sectional* dry dock. It is patented by Messrs. Dakin, Moody, Burgess, and Dodge, who are at present constructing this one for the government, a considerable portion of which is already completed, and the balance in progress. When finished this dock will consist of ten sections, each of which has the capacity to raise 800 tons—total power 8000 tons—and will take up a vessel of 350 in length. Six sections will raise a ship of the line, and the four remaining sections will raise a frigate. The sections are placed side by side, and connected by timbers at the top of the tanks. The pumps for exhausting the sections are worked by four steam-engines—two of 20 and two of 12-horse power. One of each size is used on each side of the dock, and placed so that the two 20-horse engines exhaust six sections, and the two 12-horse engines exhaust four sections, a perfect uniformity of level being maintained by suitable connections. In connection with the dock, there is a large stone basin, the sides and bottom being of granite. This basin is 350 feet long, and 226 feet wide, and contains a sufficient depth of water at ordinary high tide, to float the dock and the vessel it may contain. Immediately adjacent to, and connected with the basin, are two railways on the main land. These railways are to be of the most substantial character, and fully capable of sustaining any vessel the dock will raise. The operation of the whole is as follows:—The sections of the dock are hauled out into the river, and water let into them until they sink deep enough to allow the vessel to be floated in. As soon as this takes place, and the vessel is properly secured, the water is pumped out of the sections, and the vessel raised out of the water. When this has been accomplished, the whole is floated into the stone basin and allowed to ground on the bottom, when the vessel may be hauled on the railway. This is effected by means of a hydraulic cylinder, of 36 inches diameter and 12 feet stroke, worked by an engine of 40-horse power. If necessary, two vessels may be put on the railways, and a ship of the line and frigate left on the dock, so that the capacity of the dock is equal to four vessels of large class. When required, additional ways may be put up in connection with the basin. The whole will be completed during 1851, but some of the sections will be ready this season.

NOTES OF THE MONTH.

National Exhibition for 1851.—We have to announce that all the designs for the building will be exhibited at the Institution of Civil Engineers on the 10th June. The agitation for placing the building in Battersea Park instead of Hyde Park is taking a definite form, and is likely to be successful.

Prizes for Locomotive Engines in Austria.—An official notice has been issued by Baron Lionel de Rothschild, that the Austrian government offers six prizes for locomotive engines as follow:—A prize of 20,000 imperial ducats (10,000*l.*) for a locomotive the most suitably constructed and adapted to convey goods and passengers on the railway of the Sömring mountains, and five other prizes of the respective value of 10,000 imperial ducats (5,000*l.*), 9,000 ducats (4.500*l.*), 8,000, 7,000, and 6.000 ducats (4,000*l.*, 3,500*l.*, and 3,000*l.*) for five other locomotives, which approach nearest to the first prize in the points indicated. Plans and particulars of so interesting a competition may be had at the Imperial Royal Austrian Consulate General. New Court, St Swithin's-lane.

Great Naval Work in Russia.—In the month of February last, the great naval basin at Sebastapol was completed. The largest ships of war in the Russian navy can now be docked at that port. The basin covers an area of ten acres of ground, and has seven dry docks. The water in the basin is thirty feet above the level of the Black Sea, and the vessels are taken in by means of three locks, the iron gates of which were made by Messrs. Rennie, and are 64 feet broad, and 28 feet deep. Each of the docks has a sluice, which can be opened and the water emptied out in a very limited time, without the trouble of pumping—the plan adopted at the docks adjoining basins in this country. The Emperor of Russia is reported to have fifty ships of war at present at Sebastapol.

Aylesbury—Several plans for supplying the town with water have been forwarded to the Local Board of Health, all attended with an estimate of large outlay. P. Scott, Esq., C.E., proposes several plans, one of which is to take the supply from near Walton Mill, and erecting a pumping engine house on the Bierton elevation, the estimated cost of which will be upwards of 5,000*l.* Mr. Paten proposes a supply from Holman's-bridge stream, and an erection of steam power at the infirmary end of the town; this estimate is also over 5,000*l.* A Mr. Wrigg, an engineer from Salden, near Manchester, adopts the surface plan, and proposes several separate districts for a supply of water; each plan is estimated as costing upwards of 7,000*l.* Mr. Gotto proposes a supply from Stock Lake at a cost of 1,800*l.*; and a Mr. Gardner adopts a supply from the Friarage, and an erection of water-works in Bull Close, at a cost of 1,445*l.* A series of useful suggestions from Mr. Bell, of Leicester, was read at the meeting. To each plan there arises very difficult obstacles, and it is quite certain that if any plan of supplying the town with public water-works be adopted it will have to be done at a very great outlay.

Dover.—A kind of square vessel for the reception of machinery to be employed in breaking up and removing the solid rock at the bed of the sea where the refuge harbour is being built, whose motive power is steam, has been launched from the yard belonging to the harbour contractors, and which has been built by Mr. Cullen, ship builder, by order of Mr. Lee, the contractor of the new works. The vessel was afterwards towed into the inner harbour, alongside Mr. Cullen's yard, where it will remain until it shall have received the engines. The whole of the machinery is expected to be completed and ready for work in a short time.

Devonport.—A second attempt was made at the Keyham New Steam Docks, on the 14th, to raise the caisson, when the dam burst, and the works became inundated. The contractors, Messrs. Baker and Son, will have to repair this at their own cost. The dam was a temporary one erected for the purpose of trying the caisson, to confine the water to the lock or *spoiled dock*, and so to prevent the other portions of the work from becoming inundated during the trial. The accident, however, has obliged the parties to postpone further trial for a fortnight. Of the caisson, the *Times* correspondent gives the following account, but he has said nothing about the bursting of the work, for which the contractor was responsible:—"The water, for the first time, was let into the entrance lock on Saturday. The caisson, which is made of strong plate-iron, and is provided with a tidal valve and four sluices, measures 80 feet wide at top, 62 ft. 8 in. at the bottom, is 43 feet deep, and when immersed, gives a roadway across of 13 ft. 6 in. The weight is about 300 tons, and 150 tons of pig-iron ballast had been placed at the bottom to throw her upright. This quantity proved, however, totally inadequate, and labourers from the dockyard have been since employed throwing in additional ballast. It has been calculated that, taking the length of the caisson as 70 feet, breadth 14 feet, depth 41 feet, and weight 300 tons, her light draught, when upright, would be 10 ft. 10 in.; and that 300 tons of ballast would make her load draught 21 feet, at which point the centre of gravity would be sufficiently reduced to place her under command for bringing her to the grooves. 'This mode of closing docks is quite new in England. There is a caisson at Malta which answers well the desired object.'" The latter part of the statement is absurd, there are lots of caissons in England, as the eminent constructor of them, Mr. Fairbairn, well knows.

South Wales Railway.—The works are proceeding rapidly, and it is expected that a single line of rails will be completed between Chepstow and Swansea about the 10th of this month, and that this portion of the line will be ready for traffic early in July.

Presentation of the Royal Gold Medal to Mr. Barry, R.A.—The presentation of the Royal Gold Medal to Mr. Barry, at the Institute of British Architects, took place on the 28th ult., in presence of a very numerous meeting of the fellows and associates, and over which Earl de Grey presided. His lordship having expressed the satisfaction he felt in being called to the chair, and returned thanks for the honour done him, said it was the third year in which the prize had been distributed, and he thought it would be admitted by all that the council of the Institute had shown the greatest possible impartiality (Cheers.) The present year brought them great satisfaction, in that the honour was conferred upon one of their own body. His lordship then addressed himself to Mr. Barry, and, having made some allusions to the difficulties which had been encountered by Sir C. Wren in building St. Paul's Cathedral, said he was sorry that the august assembly which had the most to do with the erection of the new Houses of Parliament had in it a vast number of men who asked questions, made suggestions, and made criticisms, while at the same time they did not know what was wanted, or what they wanted themselves. (Cheers.) The noble chairman then presented the medal to Mr. Barry, amidst long-continued cheers from those present.—Mr. Barry, in expressing his thanks for the honour done him, said he felt sensibly alive to the defects of the great work upon which he was employed. He received the mark of approbation conferred upon him as a pledge of the opinion of the Institute that so far as he had been permitted to carry out his design, it had not been entirely unsuccessful. (Loud cheers.) He should always consider the honour done to him as one of the proudest memorials of his professional career.

Rewards, &c., for Scientific Purposes.—The following is an account, in detail, of the manner in which the 1000l. voted annually for rewards, experiments, and other expenses, for scientific purposes during the last two years, has been expended:—1847, 1848—Salary of Mr. J. W. Hay, as chemical lecturer at Portsmouth Dockyard, between Jan. 1 and June 30, 1847. 87l. 10s.; payment to Dr. Andrew Ure, for making an analysis of coal from Vancouver's island, 10l. 10s.; entertainment of Mr. F. P. Smith, patentee of the screw-propeller, on board the *Fairy*, tender to her Majesty's yacht *Victoria and Albert*, 15l. 9s.; compensation to Lieutenant Julius Roberts, Royal Marine Artillery, for his services and expenses while improving the method of pivoting guns, from the year 1845 to 1848, 250l.; total, 313l. 9s. 1848, 1849—Payment to Mr. A. G. Carle, for rock apparatus, &c., supplied for trial at Harwich, for the purpose of effecting communication with stranded vessels, 31l 8s.; gratuity to Mr. J. T. Townson, for his services in preparing tables for great circle sailing, 100l.; payment to Mr. John Pridau, metallurgic chemist, for various analyses of copper sheathing, &c., for the committee on metals, 17l. 1s; payment to Mr. Charles Brooke, for his invention and establishment at the Royal Observatory, of the apparatus for the self-registration of magnetical and meteorological phenomena, 500l.; gratuity to Commander H. B. Weston, of the Hon. East India Company's service, for discovering a method of finding the longitude by chronometer at sunrise and sunset, with tables, 100l.; total, 748l. 9s. 1849-50—Allowance to Commander A. B. Beecher, to defray the expenses incurred by him in the editorship of the *Nautical Magazine*, 50l.; allowance to Mr. James Gordon, to enable him to publish a work, intituled, 'The Lunar and Tide Tables,' 50l.' total, 100l.

Parochial Registers.—Mr. W. Downing Bruce, F.S.A., of the Middle Temple, has addressed a letter to Mr. M. Milnes, M P., on the necessity of a general Record Office being erected. The state of the registers at the present time is most deplorable; and there can be no question but that this subject requires the immediate attention of the legislature.

Fittings for the Arctic Expedition.—Excepting iron bulkheads for coal holes or side bunkers (an improvement), Downton's pumps worked on lower deck, and Sylvester's heating apparatus being extended 10 feet before foremost cabins on lower deck, all is as the *Enterprise* was. All the scuttles, or deck lights screw in and out for ventilation fore and aft: and Sylvester's stove having a current of air direct by a tube from upper deck will carry off much of the damp or condensed vapour, the ill effects of which were experienced in the last voyage. Of boats each ship has—1st, a life boat 30 feet long and 9 feet beam, built by White of Cowes; 2nd, one diagonal cutter, 25 feet long, 7 ft. 2 in. beam, fitted with trunks and windlass for laying out or weighing an anchor. Then four of 25 feet clinker-built gig cutters, or combination boats, pulling six oars, each single banked. One 25 feet whale boat of four oars as captain's gig; and one 12 feet dingy, and one 7 feet punt, the last about 80 lb. weight, and would convey safely two men at a time; in addition, they have one large and one small india rubber or Macintosh boat inflated by bellows. Total of boats, 9 of wood and 2 of air-tight India rubber Macintosh. The sledges are similar to those constructed for last expedition, but wider shoeing on the sole of the runners; the flat sledges are 6 inches wider and 2 feet longer than the last were, with a high curve in forepart. There is a gutta percha oblong trough fitted on the top of the travelling sledge, that is supported by 4 small iron uprights, passing through upper part of the sledge. This trough serves to hold the articles stowed or being strapped to the sledge, and will from its buoyancy make a tolerable boat, being only about 18 lb. weight, yet will support 6 cwt. in the water. They have a large yet light cooking apparatus, capable for baking for all hands, or heating washing water for the men, with a small proportion of fuel; they have also very compact light cooking apparatus heated by spirits of wine, and prepared cloth for tents, with bamboo poles for ditto. All the ships have been furnished with several new instruments, one of which is the Bearing Plate, the invention of Captain Johnson, R.N., F.R.S. They are for the purpose of ascertaining with greater certainty the ship's course in *dark weather*, and are particularly useful on board all steam vessels. The Lords of the Admiralty had them made by their instrument-maker (Mr. West, of the Strand) who also furnished some compasses and theodolites made of copper, to avoid any magnetic influence, and with other improvements by Captain Johnson, which are calculated to be of the greatest possible advantage to the expedition. The equipment for the travelling parties of the expedition has been arranged entirely by Lieutenant M'Clintock. It comprises 18 tents, each to hold seven persons, 18 mackintosh floorcloths, bamboo tent poles, hair rope; tin travelling kettles with spirit lamps and spun glass wicks; 14 large sledges upon runners; 12 small flat sledges for soft service; tin cans of two and four gallons each, the bung covered with a cap, which also serves as a gill measure, and secured with a padlock; pocket chronometers, pocket sextants, telescopes, and compasses; 40 gallons of spirits of wine; two wolf skin blankets for each tent; one thick blanket bag for each person to sleep in; eight gutta percha sledge tops, to adapt the sledges to crossing narrow spaces of water as rafts or boats, and thus avoid the necessity of unloading and using a boat; six of Lieutenant Halket's inflated boats; and 30 balloons to each ship.

Improvements in Electric Telegraph Batteries.—In most of the electric telegraph establishments, are batteries formed of zinc, copper, and sand, moistened with dilute sulphuric acid—this sand being strongly pressed between the metallic plates. These batteries, however much an improvement over those formerly employed, possess the great disadvantage of diminishing in force, requiring the frequent application of the dilute acid, and a complete removal once in every four or six weeks. M. W. Eisenlohr, the superintendent of the electric telegraphs in the Grand Duchy of Baden, has for some time past endeavoured to find out some method of rendering the battery more constant in its action, and at the same time less liable to the carelessness of the workmen, who sometimes put too much acid, and at other times leave the battery quite dry, thus producing a great interruption in the working of the telegraph. After various experiments on the subject, M. Eisenlohr found that the employment of a solution of bitartrate of potash in acidulated water for the zinc couples of a Daniell's battery, and of a moderately concentrated solution of sulphate of copper for the copper element, fully and effectually answered the desired object. This battery was found to possess a remarkable constancy. M. E. Watermann, in speaking of this new battery in the last number of the *Bibliothèque Universelle* of Geneva, states that he has made use of Daniell's battery of ten couples, charged on M. Eisenlohr's system, but placing the zinc couples in acidulated water, and the copper in a solution of bitartrate of potash, and that the battery, which remained in action for three weeks, without any interruption, exhibited the most perfect constancy.

The Great Harbour of Refuge at Holyhead.—The want of a great harbour of refuge on this exposed coast has long been felt; and when it is borne in mind that the greater portion of the vast fleets destined for Liverpool must pass near Holyhead, the national importance of such an undertaking cannot be exaggerated. Plans by Mr. Walker and Captain Beechy, R.N., were rejected, and one on a more important scale by Mr. Rendel, who has carried out several great public works, was adopted by the Admiralty early in 1846. The estimate is 700,000l., of which the Chester and Holyhead Railway Company have agreed to find 200,000l. The works were soon commenced, but have gone on rather slowly, and 10 or 15 years will probably elapse before they are completed. A visit to the scene of this great undertaking is one of the chief attractions of Holyhead. Nature has given Mr. Rendel valuable aid. There is a point called Penrhyn, about 1½ mile to the north-west of the present harbour, whence an indented rocky coast runs south east. Considerably within this, at Soldier's Point, a gigantic breakwater is in progress, the stone for which is procured from a quarry in the mountain, one mile inland, to which a railway of prodigious guage, for stone trucks, worked by locomotives, up a very steep incline, has been formed. The breakwater will terminate at Platter's Buoy, and a pier of 7500 feet will be carried from Ynys Gybi, with its head resting on the Outer Platter. The arena inclosed within this half-moon will be 316 acres; the length across will be ¾-mile. There will be a jetty in the centre, and ample depth of water (none less than 6½ fathoms) at all states of the tide.

Steam Haulage on Rivers and Canals.—An experiment has lately been tried, with complete success, on the Gloucester and Berkeley Canal, of a somewhat novel steam-tug for hauling vessels instead of horse-power. It consists of a continuous flexible rail, or bar of iron, running the whole length of the canal, and made fast at each terminus. Above the deck of the tug are fixed a pair of rollers, between which this flexible iron band is placed, and as they are made to revolve by the steam engine on board, the grip which they take propels the boat. On the trial in question, after hauling various small craft of from 70 to 80 tons burden, she took in tow a Greek brig, laden with corn to the amount of 350 tons, which she towed against a head-wind to the dock entrance, at a good walking pace. She hauled the common canal boats at a rate of 6 miles an hour, the speed being but little affected when going against tide. The cost of hauling in the Severn is a heavy item in the transit of goods, and this invention is calculated to diminish the expense 50 per cent., the consumption of coal being only 25lb. per hour.

Effluvia Trap.—We have seen a patent effluvia trap of Mr. Marsden's, which well answers the purpose. It is constructed in the shape of a drum, with four receivers, caused to revolve by the weight of the water falling into one of them. It is impossible for this trap to get choked up, or for any effluvia to escape.

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM APRIL 23, TO MAY 23, 1850.

Six Months allowed for Enrolment, unless otherwise expressed.

Pierre Armand Lecomte de Fontainemoreau, of South-street, Finsbury, for a new and improved mode of conducting consuming, and disengaging smoke from its deleterious components. (A communication.)—April 23.

Ernest Werner Siemens, of Berlin, Prussia, electric engineer, for improvements in electric telegraphs.—April 23.

Joseph Jean Baranowski of London, gentleman, for improvements in machinery for counting, numbering, and labelling.—April 23.

William Gilbert Elliott, of Blisworth, Northampton, gentleman, for improvements in the manufacture of bricks, tiles, and pipes, and other articles from plastic materials. (A communication.)—April 27.

Charles May, of Ipswich, engineer, and Robert Leggett, of the same place, foreman of mechanics to Messrs. Ransome and May, of the same place, for improvements in machinery for thrashing and grinding corn, for cutting straw, and other similar substances; also improvements in applying steam-power to give motion to such classes of machinery; and also improvements in machines for depositing seed.—April 30.

George Michiels, of London, gentleman, for improvements in treating coal and in the manufacture of gas, and also in apparatus for burning gas. (A communication.—April 30.

Evan Protheroe, of Austin-friars, London, merchant, for improvements in the manufacture of oxide of zinc, and in making paints from oxide of zinc. (A communication.)—April 30.

Robert Dalgliesh, of Glasgow, merchant and calico printer, for certain improvements in printing, and in the application of colours to silk, cotton, linen, woollen, and other textile fabrics.—May 7.

Gustave Eugene Michael Gerard, of Paris, France, for improvements in dissolving caoutchouc (Indian-rubber) and gutta percha.—May 7.

George Hurwood, of Ipswich, Suffolk, engineer, for improvements in grinding corn and other substances.—May 7.

Joseph Gibbs, of Devonshire-street, Portland-place, Middlesex, civil engineer, for improvements in artificial stone, mortar, and cements, and in the modes of manufacturing the same.—May 7.

John Tatham and David Cheetham, of Rochdale, Lancaster, machine makers, for certain improvements in machinery or apparatus and operations connected with the manufacture of cotton, wool, silk, and other fibrous substances and fabrics, and in the application of certain materials to the manufacture of textile fabrics.—May 7.

George Robbins, of Forrest Lodge, Southampton, gentleman, for improvements in the construction of railway carriages.—May 7.

John Youil, of Ardwich, Manchester, brewer, for certain improvements in machinery or apparatus for washing, cleansing, filling, and corking bottles and other vessels.—May 8.

William Edward Newton, of Chancery-lane, civil engineer, for improvements in warming and ventilating buildings. (A communication.)—May 22.

Robert Cotgreave, of Eccleston, Chester, farmer, for certain improvements in machinery or apparatus to be used in draining land.—May 22.

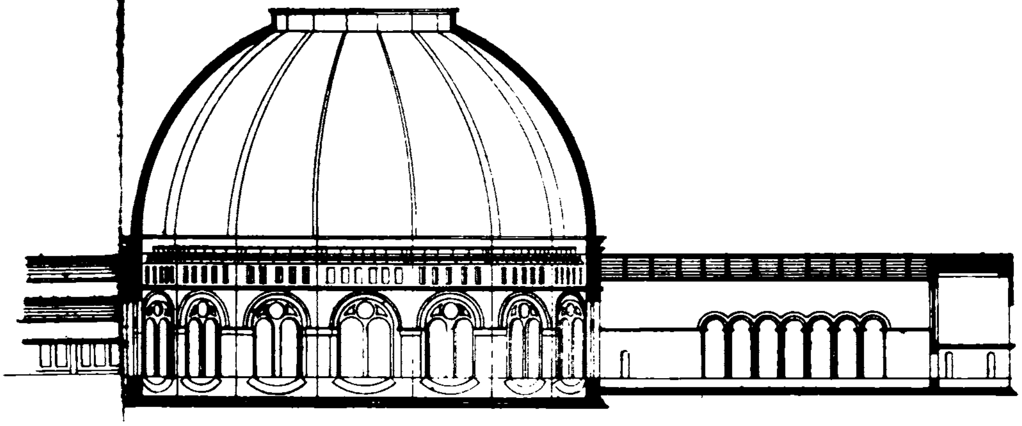
Henry Columbus Heurry, of Manchester, civil engineer, for certain improvements in the method of lubricating machinery.—May 22.

William Palmer, of Cottage-grove, Bow-road, Middlesex, gentleman, for improvements in the manufacture of candles and candle-wicks, and in the machinery applicable to such matters.—May 22.

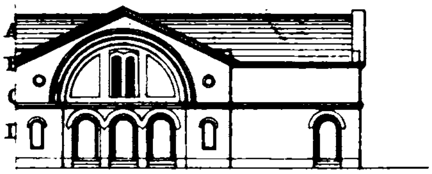
Jules Frederick Maillard Dumeste, of Paris, for certain improvements in reflectors for luminaries.—May 23.

Simon Pincoffs, of Manchester, Lancaster, merchant, for certain improvements in the ageing process in calico printing and dyeing, which improvements are also applicable to other processes in calico printing and dyeing.—May 23.

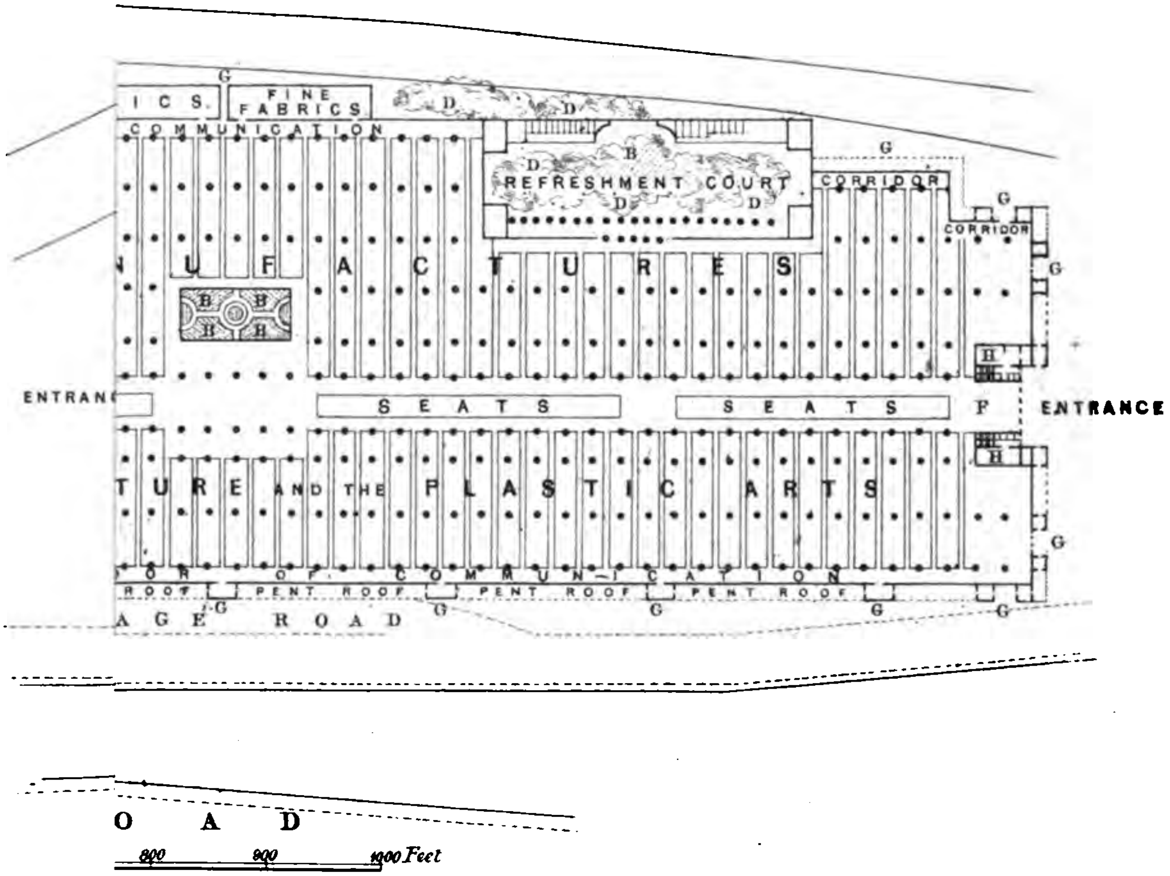
ALL NATIONS.



N TROUCH CENTRE HALL ON THE LINE A.B.



E.E.E . Offices of the Refreshment Depart^{mt}
F.F.F. Halls.
G.G.G. Doors of exit.
H.H.H. Accountants.



R Jobbins.

GREAT EXHIBITION OF INDUSTRY OF ALL NATIONS.

(*With an Engraving, Plate* VIII.)

In our last number we gave a short reference to the various designs sent in for the Exhibition Building in 1851; in our present we give an engraving, showing the plan proposed by the Building Committee, as the result of their investigations. It will be satisfactory to many of the competitors to find that the design of the Committee is formed on the same system as their own. One grand view is given through the building, from east to west, by an avenue under the highest roof, and which will be appropriated for seats, so that the visitors can scarcely fail to have their attention called to the *coup d'œil*. The general arrangements are good, but a grand dome is provided, on which we have more to say.

Besides the central avenue, a corridor of communication is provided around the building, and the spaces covered with trees are appropriated as refreshment courts, likewise serving as centres of transit, so as to facilitate access to the several departments. The entrances are four in number—the outlets all around the building. The elevations are sufficiently effective, without any attempt at display.

The iron dome, two hundred feet in diameter, or cone, as it is likewise suggested, is made the chief feature, but we question very much the expediency of the suggestion. Undoubtedly, it would be a great triumph of English art, to erect such a work; but we cannot help looking to circumstances, the more particularly when no such exertion is needed, as the contents of the building will be a sufficient demonstration of our powers and resources. It is better to rely on the book than on the binding—on the jewels than on the case—on the exhibition than on the building. The *spectacle* should consist in the objects shown, and we should not give in to the false taste of seeking to make the building itself a *spectacle*. In St. Petersburgh and in Paris, such an auxiliary as a colossal dome might be required; but we need no such *éclat*. The ocean steamer, which conveys the distant visitor—the railways, which bring him within the metropolis—the bridges which span the river—will strike him with wonder enough, and give him a full conviction of our engineering and constructive power. As a matter of taste the dome is not wanted; we think we have given sufficient reasons why it is not wanted as an object of display. Use it has none; for appropriated to works of sculpture, the most colossal bronze we have—even the Wellington statue, if brought across the road, will seem a pigmy under the vast vault.

While there is, in our humble judgment, no reason for making the attempt, we question very much whether the attempt to construct such a dome by the spring of next year will be successful, great as are our resources. A failure will injure us in the eyes of foreigners; success cannot win from them a higher opinion of our skill, while whatever the funds at the disposal of the Commissioners, there are so many urgent demands upon them as to render the outlay for a dome very undesirable.

Although all the details of the lighting are not given, there is sufficient in the plan and elevation to show that top-lighting by skylights is extensively used, which, for most objects of exhibition, is far from being favourable. A skylight gives the very worst light for most ornamental objects; and as the Exhibition will be held in the summer months, when sun light and heat are strongest, many delicate works must be very much injured, although a great expense must be gone to for blinds. We think it very desirable that side lights should be put in above the gutters in the central roof, and likewise, as far as possible, in the refreshment courts, and on the outside of the building. We are well aware there is an objection to have openings in the walls, which might give facilities for the removal of goods; but in a building so well guarded we consider this of little weight.

An arrangement, which we likewise consider as affording insufficient accommodation, is the height of the walling, which being 25 feet, is not enough for the display of carpeting and other goods of extensive area. The height ought to be at least 40 feet.

The building will certainly be vast in its proportions—beyond anything which we have seen in London; for its length is about 2325 feet, whereas the Houses of Parliament have a façade of 875 feet, London Bridge of 1005 feet, and Waterloo Bridge of 1326 feet. Thus the façade of the Exhibition Building is above twice the length of London Bridge, and thrice that of the Houses of Parliament. The breadth of the Exhibition Building being about 450 feet, and the area 1,000,000 square feet, the space roofed is far greater than the area of Lincoln's-inn-Fields, or of the great Pyramid of Gizeh. Never before was there a building so vast got up for a like purpose; for the dimensions of the Paris Exposition, as shown in the engraving in the December number of the *Civil Engineer and Architect's Journal*, are 800 feet long, and 330 feet wide, constituting an area of 261,000 square feet. Thus the London Exposition will have a façade thrice the length, and an area four times greater.

The area of 1,000,000 feet will be covered with one roof, except at the dome and the small refreshment courts; and the least height of this roofing will be 24 feet high, the greatest 50 feet. The spans will be 48 feet, except at the centre, where it will be 96 feet over the line of seats. Not only will there be a vast roof, but likewise a vast flooring, formed of boarding, laid on joists and sleeper walls.

We are glad to see that, notwithstanding the invitations of foreign architects and the compliments paid to them, the design and construction of the building adopted is to be under English auspices.

LECTURES ON THE HISTORY OF ARCHITECTURE;

By Samuel Clegg, Jun., M.I.C.E., F.G.S.

Delivered at the College for General Practical Science, Putney, Surrey.

(PRESIDENT, HIS GRACE THE DUKE OF BUCCLEUCH, K.G.)

Lecture VII.—ATHENS: *Fortifications—Temples.*

In contemplating Attica, the first sensation must be that of wonder that a spot of earth so minute as scarcely to be perceptible on the chart of the world, should have exerted so great an influence over the whole civilised globe—an influence felt in thought, in speech, and above all, in art, even to the present day. There is something sublime in the idea of a small state, naturally barren and comparatively poor, solely by the moral and intellectual energy of its inhabitants, rising like a giant to stretch its mighty shadow over all ages and all lands. Athens itself is surrounded by a halo of bright associations,—the Αστυ, one of the eyes of Greece—the learned city—the school of the world.

Great nations have risen, have conquered, and have passed away, leaving scarcely a ripple on the ocean of time—for their's was but physical power, and by nature finite; but the thoughts of great men and the works of genius, like the immortal soul from which they emanate, live for ever, to gladden the hearts of unborn generations.

While Thessaly and Arcadia boasted their rich woods and plains, the mountainous district of Attica afforded but a scanty support for a few shrubs and a thin vegetation; and in many parts the bare calcareous rock, rising above the soil, defied altogether the hand of the husbandman. But this sterility proved a boon instead of a curse: all the activity and courage of the inhabitants was called forth by necessity, that first great practical teacher. The Athenians were driven to undergo danger and difficulty abroad, in order to supply the wants of home: instead of being cooped-up within the limits of a narrow sphere, they acquired a love for enterprise and adventure; thus, at the earliest period of their history, attaining that ardour and energy of character that produced their after-greatness. Another influence was equally felt by the Athenian. The barren country of Attica had offered few inducements to the invader: the people imagined themselves its indigenous inhabitants, and were accustomed to weave golden grasshoppers in their hair to denote that they also were children of the soil. This belief gave them a passionate attachment to their native land—to those hills and plains on which no proud conqueror had ever set his foot. This patriotism—this strong love of country—prevented that overweening selfishness, always so great a barrier to progress, and brought the wanderer in search of learning, wealth, or fame, home, to enrich his beloved Athens with his accumulated treasure.

The original city of Athens was limited to the Acropolis, then called Cecropia, after its supposed founder, Cecrops, who lived about the same time with Moses. He was succeeded by a long line of kings, the most memorable of whom was Theseus. This hero is said to have given new laws to the country, and to have founded the Prytaneum as a court of justice for the whole of Attica. He also established the Panathenaic festival; and, by these means, attracted a great concourse to Athens, which thenceforward became the capital of Attica, about 1300 B.C. At the death of Codrus (1091 B.C.) monarchy was abolished, and popular freedom gained ground, until in the year 684 B.C. a democracy was firmly established, the head of the state being a magistrate, chosen annually, under the name of archon.

From this time Athenian power steadily increased. Solon and Pisistratus flourished at the same period (between 500 and 600 B.C.); and though differing widely in other respects, they both agreed in honouring the arts and sciences. Solon, by his laws, encouraged the fine arts, whilst Lycurgus, on the contrary, forbade their cultivation: thus it was (as an ancient writer observes) that Lacedæmon has left no sign of its greatness, while Athens, from the aspect of its ruined city, would appear to have had more power than it in reality possessed.

Pisistratus founded a public library, and adorned the city with other buildings. Before the time of the Persian invasion under Xerxes, the yearly revenue of Attica did not exceed 130 talents, or 300,000*l.*; but the event which threatened its destruction was, in reality, a source of wealth and greatness. Attica, by its geographical position, was peculiarly adapted for a maritime country; its statesmen therefore turned their chief attention to the organisation of a fleet; and it was principally by the Athenian navy that the battle of Salamis was won, Xerxes driven from the country, and the supremacy gained over the other states of Greece.

Athens had been laid waste by the Persians, but rose, like a phœnix, from its ashes. Riches poured into the treasury from the spoils of enemies and the contributions of allies, a tithe was set apart for the restoration of the city, and the excitement of the people, so lately engaged in a struggle for existence, found a vent in the rapid progress of the public works.

It was during this period of fifty years, from the defeat of the Persians to the commencement of the Peloponnesian war, that the most splendid edifices were erected, under the several administrations of Themistocles, Cimon, and Pericles, and that the arts arrived at their highest point of perfection.

The first of these great men, after the devastations of war, naturally turned his attention to works of utility, commencing the long walls between Athens and the Piræeus, and fortifying the ports. The magnificence and liberality of Cimon rendered him desirous of adorning as well as strengthening the city; and though at this time (465 B.C.) the common treasury was transferred from Delos to Athens, such was the munificence of Cimon, that many of the works were carried on at his own private expense. Under his administration the Temple of Theseus and the portico, called Pœcile, were erected, the Academy and public gardens laid out and planted, and the great Dionysaic theatre commenced. The brightest era of Athens had now arrived, and at the same time a statesman arose, fitted above all others, by his cultivation of mind, taste, and eloquence, for the advancement of his great object, the prosperity and splendour of his native city.

It was the good fortune of Pericles, that in his time, artists existed capable of carrying out his ideas; and it was also the good fortune of Phidias, Ictinus, Myron, and Polycletus, to have been employed by one so fully able to appreciate their genius. Thus, in the course of a few years, were accomplished works which have been the wonder of ages; works not only magnificent in design and exquisite in execution, but erected with such attention to durability, that after the expiration of a thousand years, they were ruined by the wantonness of man rather than by the finger of time.

Plutarch observes, speaking of the buildings of this period, "A bloom is diffused over them, which preserves their aspect untarnished by time, as if they were animated with a spirit of perpetual youth and unfading elegance." The enemies of Pericles accused him of lavishing the money of the allies in gilding the city of Athens, and ornamenting it with statues and temples, as a vain woman decks herself with jewels. To this Pericles replied, that, "as the state was provided with all the necessaries of war, its superfluous wealth should be expended upon such works as, when executed, would be eternal monuments of its glory, and which, during its execution, would diffuse universal plenty: for as it was requisite to appropriate so many kinds of labour, and such a variety of instruments and materials to these undertakings, to exert every art, and employ every hand, almost the whole city would be in pay, and be at the same time adorned and supported by itself." Pericles demanded of the people, "whether or not they thought that he had expended too much?" They answered in the affirmative. "Then be it," said he, "charged to my account, not yours; only let the new edifices be inscribed with my name, not with that of the people of Athens." The Athenians however would not agree to this, and answered, "that he might spend as much as he pleased of the public treasure, without sparing it in the least."

Pericles might probably have embellished the city to a still greater extent had peace continued, but in 431 B.C. the Peloponnesian war broke out, which, lasting twenty-seven years, demanded all the resources and energies of the Athenians. In the time of Conon (400 B.C.) Athens for a time recovered her supremacy; the Dionysaic theatre was now completed, a gymnasium constructed in the Lyceium, and a stadium for the celebration of the Panathenaic games.

But a power was soon to arise before which all others had to bow. Alexander the Great was born 355 B.C., and from his time may be dated the loss of the freedom of Greece. With the loss of liberty, the love of glory that animated her people declined; that sublimity of spirit which had distinguished her artists was gone, and the arts languished in decay. Athens nominally preserved her independence by an alliance with Macedonia, but her archon was supported by a Macedonian garrison. From this time, sometimes in alliance with Macedonia, sometimes with Rome, she was plundered by both. But though her naval and military power was broken, and the brilliance of her schools of art and philosophy dimmed, she was still regarded with a kind of reverential awe; and the education of a young Roman patrician was thought incomplete unless he had studied in the schools of Athens.

Though Greece did not become a Roman province till the time of the Emperor Vespasian (69 A.D.) she had long been beholden to foreign powers for any public works that were carried on, and Greek art may at this time be said to be lost in that of Rome.

I will now endeavour to trace the position of the principal buildings of ancient Athens, that some idea may be formed of the appearance and arrangement of this once beautiful city. Nearly in the centre of the town rises the Acropolis, a craggy, abrupt, limestone rock, seemingly formed by nature for a citadel. It is oblong in form, lying from east to west, about 150 feet in height, rather more than 900 feet in length, and 480 feet in breadth. High up the sloping road to the west stands the great Propylea, which, with its wings, occupies the whole natural entrance to the Acropolis. Before the southern wing stands the small Ionic Temple of Victory, without wings, on which Ægeus stood to watch for the return of his son Theseus from Crete, and whence he cast himself in despair when the black sail appeared in sight. The Acropolis was holy ground; no dog or goat was allowed to enter its sacred precincts. Here were found the works of Phidias and Praxiteles, of Polycletus and Alcamenes, representing the gods and heroes of Athens. Wherever the eye turned, some sacred object presented itself—some form of beauty caused the footstep to linger. So numerous were the decorations of the Acropolis, that Pliny mentions no less than 3000 statues as standing there in his time.

On the highest point of ground is the Parthenon, the great temple of the tutelary goddess; and on the northern side the Erechtheion invites the devout to offer sacrifices to Minerva Polias, and the nymph Pandrossus. On the other side rose the colossal brazen statue of Minerva, the glittering point of whose spear was visible as far off as Sunium. Below, on the southern side of the rock, are the long ranges of seats belonging to the great Theatre of Bacchus and the Odeion of Regillæ. These were connected by the Eumenic Stoa. Next, towards the east, was the Odeion of Pericles, still within the Temenos of Bacchus. The street of Tripods extends from here to the Prytaneiam, under the north-east angle of the rock.

Standing at the entrance of the Propylea, and looking towards the west, the first object only separated by a narrow gorge, is the hill of the ancient court of Areopagus. In the eastern corner, overshadowed by dark trees, stands the Temple of the Furies, those fearful goddesses whom no Greek could mention without a shudder, and who caused even the spoiler Nero to turn trembling away from Athens, as the place of their abode. Yonder is the Pnyx, with its rough hewn walls, and bema, or pulpit, from which Demosthenes used to address his excited audience; and beyond again stretched the Long Walls, onwards to the bustling port Piræeus, crowded with shipping and merchandise. Afar off to the north-west, is visible the sacred city of Eleusis, with its temples and propylea; the holy gate Dipylum standing between the outer and inner Ceramicus, leads to the Eleusinian road. The Ceramicus was planted with groves, and adorned with porticoes and statues. The old Agora occupied part of the inner suburb; and in this were streets, taking their name from the different trades carried on there, as the street of the makers of Mercuries, the street of cabinet-makers, &c. Beyond the gate Dipylum, at the extremity of the outer Ceramicus, was the Academy, celebrated for its grove of tall plane trees, beneath the shade of which Plato taught. Within the suburb, a little to the north, stands the Temple of Theseus; and between this and the Prytaneium was the new *Agora*, and the tower or horologia of Andronicus Cyrrhestes.

Let us now turn to the south-east, where the Ilissus flows past the city, and where the Calhirroë springs, the only natural fountain of sweet water in Athens. On an island, formed by the Ilissus, stood the Eleusinium, a building so sacred, that when the inhabitants of Attica crowded within the fortifications of Athens, on the breaking out of the Peloponnesian war, the Acropolis and the Eleusinium were the only places they scrupled to inhabit. In this temple the lesser mysteries were celebrated.

On the northern bank of the river is seen the great peribolus and Temple of Jupiter Olympius; and, on the south, the stadium appropriated to the Panathenaic games. Following the course of the Ilissus we reach the Lyceium, the school of Aristotle and his peripatetic disciples; and at the foot of Mount Anchesmus was the Cynosarges, the sacred grove of Hercules, where Antisthenes founded the school of cynic philosophers. On all sides without the city gates were cemeteries and monuments; and beyond, over the country, spread the different demi, or districts studded with villas, and planted with olive groves and vineyards.

Nor were the Athenians unmindful of the poor; for we are told that there were no less than 300 places where the destitute might find warmth and shelter for the night.

To return to the Acropolis and its fortifications. The walls of the citadel show traces of various periods, some parts being composed of those unhewn blocks known as Cyclopean; others of accurately fitted polygonal blocks; and others, near the entrance, show a later style, the stones being placed in regular courses, with the joints broken as in modern masonry. The polygonal masonry appears to have been the work of the Pelasgians, who were sent for to fortify the citadel, as being the best military architects; and a space of ground below the northern side of the wall, allotted for their residence, was called the Pelasgicon.

Shortly, however, the Athenians became jealous of their assistants; the Pelasgians were driven from the country, and it was ordained that the Pelasgicon should in future lie waste, for the better protection of the citadel. After the destruction of the city by the Persians, the walls of the Acropolis were repaired so hastily that the ruins of the old buildings were used in its construction. Many architectural fragments may yet be seen in different parts. The walls enclosing the city were about 7½ miles in circuit; they were 60 feet in height, and were composed of massive rectangular blocks of stone, fastened together with iron cramps, run in with lead. This manner of fastening the blocks was very common in Greece, where cement was seldom used. The stones are now frequently found bored with holes, made for the purpose of abstracting the metal.

A beautiful example of Greek masonry exists in the pavement of the Propylea at Eleusis. It consists of blocks of Pentelic marble, 6 feet in length and breadth, and 13 inches thick, so exquisitely fitted that the joints are in many places imperceptible.

In the time of Themistocles, in order to prevent the enemy from cutting-off the communication between Athens and the Piræeus, the celebrated Long Walls were commenced, 475 B.C.: they were continued by Cimon, and finished by Pericles. These walls, including the city, and extending in a double line thence to the ports, and nearly encircling the Munychian Peninsula, were about 19 miles in length, and were flanked at intervals by towers. Where the ground was marshy, the foundations were laid with chalk and large blocks of stone; and upon these the walls were raised, so wide that two loaded wagons could pass on the summit. They were in part overthrown by the Lacedæmonians, after the Peloponnesian war, but rebuilt by Conon, after an interval of ten years, and were finally destroyed by Scylla (86 B.C.)

Of the three ports of Athens, Phalerum, Munychis, and Piræeus, which once vied in dignity with the city itself, few ruins remain; the ease with which statues and fragments could be carried away, rendering them a tempting prey to the spoiler. The sites of several buildings may yet be traced, as that of the Piræic theatre and the Agora, called Hippodamia, after the architect Hippodamus.

Many splendid structures are described as existing at Phalerum, the most ancient port. Amongst the rest, the altar inscribed "to the unknown gods;" but all these have long since disappeared.

The Spartans pursued an opposite course to the Athenians. It was the policy of Lycurgus to dissuade them from fortifying their city, preferring that they should trust to their own bravery as the best means of defence. It is to be observed, however, that the whole country of Lacedæmon is naturally fortified by the steep mountains that surround it.

The most interesting example of ancient fortification now remaining is the wall of Messene, built from the plans and under the superintendence of Epimanondas, after the defeat of the Lacedæmonians at Leuctra (371 B.C.)

The kind of masonry with which these walls are composed was called *empleeton*, having faces of rectangular stone blocks in regular courses, filled-in with rubble work. The two faces of the wall are bound together by transverse courses, or through stones, placed from 7 to 10 feet distant.

Towers were erected at intervals along the wall, of rectangular form, with the exception of two on the north-east side, the fronts of which are semicircular. The towers consist of two stories, with windows and embrasures in each. In the lower story they were splayed to facilitate the discharge of missiles. Flights of steps led to the top of the wall and to the towers from the interior of the city. One of the gates was double, enclosing a circular court 63 feet diameter. There was also an outer area 31 feet in breadth, defended by the projecting walls. On the paved road leading from the inner gateway into the city, the marks of wheels are still visible.

The walls of Pharsalia are similarly constructed, and are 15½ feet in thickness.

The ancients bearing the shield on the left arm, the right side was comparatively unprotected. This influenced the Greek mode of fortification in the plan of the approaches and the position of the towers. If an enemy were climbing the road leading to the entrance of the Acropolis of Athens, their right side would be exposed to the defenders during the whole ascent.

The masonry principally employed by the Greeks was either the before-mentioned empleeton, the isodomon, in which the courses are of equal height, or the pseudo-isodomon, where the courses differ both in height and in the length of the stones. The roads were paved with oblong blocks of stone.

Greece is remarkably rich in stone and marble. In Attica alone are the quarries of white Megarian, the grey stone of Eleusis, the bluish Hymettian, the veined Carystian, and above all, the snowy marble of mount Pentelicus. The buildings of the age of Pericles are all constructed with Pentelic marble, which, on account of its white and glittering surface, was, for architectural purposes, preferred to the more creamy Parian. Time, however, has brought their comparative excellencies and defects to light: while the Parian hardens with age, and presents a beautiful and wax-like surface, the Pentelic is apt to decompose, from being traversed by veins of extraneous matter. Works executed in this marble are now, therefore, somewhat rough and earthy in appearance.

Dr. Clarke gives an interesting account of his visit to the quarries of Paros. He says: "We seemed to view the grotto exactly according to the state in which it had been left by the ancients. All the cavities, cut with the greatest nicety, showed to us, by the sharpness of their edges, the number and size of every mass of Parian marble which had been removed for the sculptors of ancient Greece. If the stone had possessed the softness of potter's clay, and had been cut by wires, it could not have been separated with greater nicety, evenness, and economy. The most evident care was everywhere displayed, that there should be no waste of this precious marble." The following anecdote may give some idea of the value of marble amongst the ancients:—When the Ephesians were about to erect a temple to Diana, they met to consult upon the best means of procuring material; the quarries then worked were far off, and the cost of transport would have been enormous. While they were deliberating, a shepherd of the name of Pyxodorus happened to be feeding his flock on Mount Pion, or Prion, near the city; and two rams beginning to fight, one of them missing his aim, struck his horn against the rock and broke off a fragment, which proved to be of the purest white marble. The shepherd immediately ran with it into the city, where it was received with acclamations of delight. Pyxodorus was in consequence, not only honoured, but canonised, his name being changed by the grateful Ephesians to Euangelus, 'the good messenger.'" A monthly sacrifice was offered to his memory, on the spot where the discovery was made; and this custom continued to the time of Augustus Cæsar.

After providing for the defence of his city, the next care of the devout Greek was to erect fitting temples to the gods.

The pious Athenian believed himself under the protection of some particular divinity, in every event and circumstance of life. Each profession and employment had its tutelary god. The sailor sacrificed to Neptune and Amphitrite; the student to Apollo and the Muses; the artist to Minerva; and the hunter to Diana. The Temple of Bacchus was situated near the theatre, where that festive god presided. That of Ceres was in the open plains, where the husbandman might pursue his daily toil under her protecting influence. Every fountain had its attendant nymph, and every grove its dryades, who were propitiated by offerings of milk, oil, and honey.

After the successful termination of any enterprise, gratitude was expressed to the favouring god by votive offerings, the warrior presenting shields and armour; the agriculturist his first fruits; and each worshipper according to his ability and avocation. These offering were sometimes of great value, and were preserved in the temple, or the sacred inclosure.

In nothing did the Greeks display their sense of beauty and love of the picturesque more than in the choice of a site for their temples. They were generally placed on elevated ground, where they could be seen from afar, as the Parthenon, and those of Jupiter Panhellenius at Ægina, and Minerva at Sunium. Where this was not the case, they were separated from the noise and bustle of the city by their peribolus, or sacred inclosure, which was adorned with statues and altars, and planted with trees; thus inviting meditation by the charm of repose. In some instances the peribolus, or temenos, was so extensive as to contain other inferior temples, and even theatres and porticoes; as the groves of Jupiter at Olympia, and of Æsculapius at Epidaurus. The peribolus was frequently surrounded by a peristyle, and contained the dwellings of the priests, and all those employed in the service of the temple. These, with their families, formed a village within the peribolus, and lived, as it were, under the immediate protection of the divinity.

The Greek temples were rectangular in form. A few ruins of circular buildings have been found, called by the Greeks "tholi;" but it appears uncertain whether these were sacred structures. The temple was raised above the level of the peribolus by a platform or stylobate; sometimes this was ascended by steps only in the front; but where there was a peristyle the steps of the stylobate were continued all round. Vitruvius recommends that the number should be unequal, that the level of the temple may be gained by the right foot. Three was the customary number in the Temple of Diana Propylea at Eleusis; however, there are five; and in that of Theseus at Athens, only two. This is supposed to have distinguished it as a heroum, or temple to an inferior divinity.

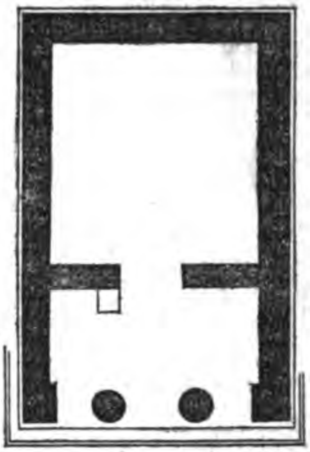
The stylobate occasionally formed a sort of area round the building. On this it was the custom to place a large altar in front of the naos, as at the Temple of Minerva at Priene, on which public sacrifices were offered, in view of the congregation assembled in the peribolus. Access to the naos or cella was prohibited to the populace; this was denoted by a cord extended across the doorway. The proportions of the temple differed according to the number of apartments required. Sometimes, in addition to the cella, there was a pronaos; sometimes both a pronaos and a posticus; and generally in the larger temples, an opisthodomos also, where the treasures and sacred utensils were kept.

Frequently, the opisthodomos of the principal temple was the public treasury of the state; this was the case at Athens, and at Delphi. The interior of the cella was lighted through the roof; or, sometimes by the door only. On the recurrence of great festivals, the whole interior of the temple was artificially illuminated.

In the earlier temples the roofs were formed of tiles, or terra-cotta, stuccoed and painted; but Byges of Naxos, who lived in the time of Solon, about 380 B.C., invented a mode of roofing in marble, for which he was honoured with an inscribed statue, a mark of distinction equivalent to a title in the present day. This invention consisted in the means adopted to prevent the water oozing through the joints of the flat marble slabs. This was done by placing over them ridges of small slabs, resembling tiles. At the extremities of each ridge, antifixæ were placed, generally in the palmette form. Below the antifixæ was a channel for the water, which passed off through the perforated lions' heads on the crowning member of the cornice.

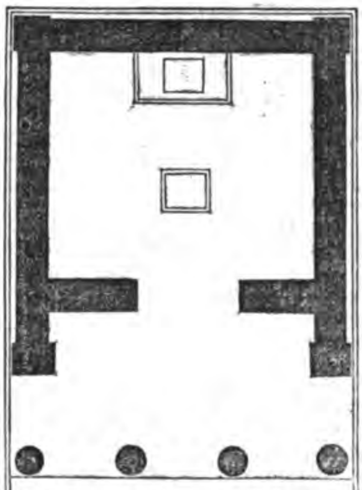
Vitruvius directs that the lions' heads over the columns should alone be perforated, while the intervening ones are left solid, to avoid the inconvenience of water dripping upon persons entering the peristyle.

Greek temples are divided by Vitruvius into seven classes, which he denominates *in antis*, *prostyle*, *amphiprostyle*, *peripteral*, *dipteral*, *pseudo-dipteral*, and *hypæthral*; though few of the Greek examples exactly agree with the rules laid down by Vitruvius, they bear a sufficiently close resemblance to be thus classified. The temple *in antis* (or as the Greeks termed it, *naos en parastasin*) is the most simple, consisting merely of a cella, the walls of which are terminated in front by antæ, or pilasters, between which two columns are placed, supporting the entablature; the whole is crowned by a pediment.

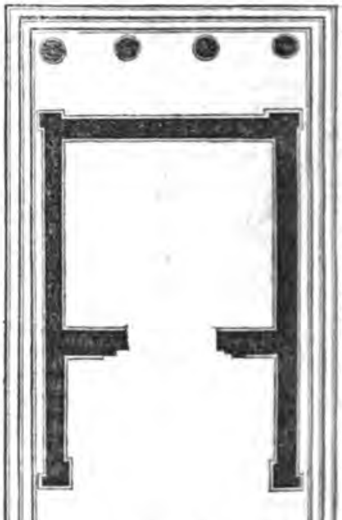


Temple in Antis——Themis at Rhamnus.

A beautiful example of an Ionic temple *in antis* was found in Asia Minor, a drawing of which is given in the 'Ionian Antiquities,' published by the Dilettanti Society. There is also an ancient example at Rhamnus in Attica, called the Temple of Themis; this is constructed with polygonal blocks of marble, and is of the Doric order; it is only 35 feet in length by 25 feet in breadth. A variety of this class is seen in the Temple of Diana Propylea at Eleusis, in which the form of the front is repeated in the rear, thus being to the simple temple *in antis* what the amphiprostyle is to the prostyle. In the Temple of Esculapius at Agrigentum, there are two engaged columns between the antæ in the rear. The great Temple of Ceres at Eleusis was *in antis* until the time of Demetrius (307 B.C.), when the architect Philo added to it a magnificent dodecastyle portico, thus bringing it under the second class, the prostyle. This was similar to the temple *in antis*, only with the addition of a portico; the angular columns of the portico are placed in front of the antæ, terminating the wall; in this class a pronaos, or vestibule, was sometimes added to the cella.



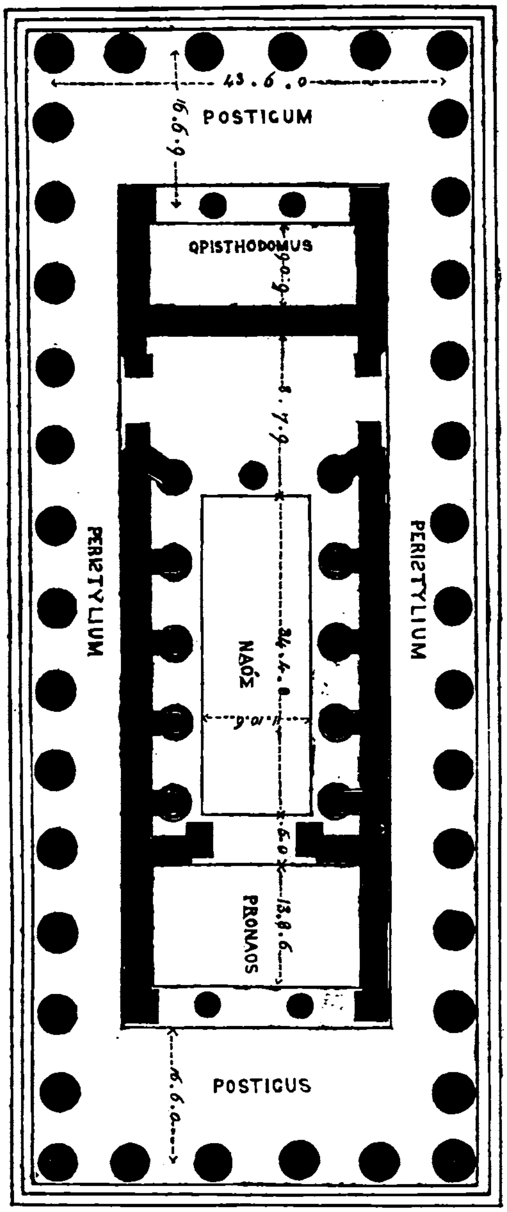
Prostyle Temple at Selinunte.



Amphiprostyle Temple on the Ilissus.

The amphiprostyle temples have a portico in the rear, as well as one in the front; this posticus is generally added when a second entrance is required. An example of this class is the Ionic temple on the Ilissus, a restoration of which is given in Stuart's 'Athens.' The larger Greek temples are mostly peripteral; that is, they have an ambulatory or peristyle along the flank, as well as porticoes in front and rear. Of this class is the Temple of Theseus at Athens, now in better preservation than any building of ancient Greece.

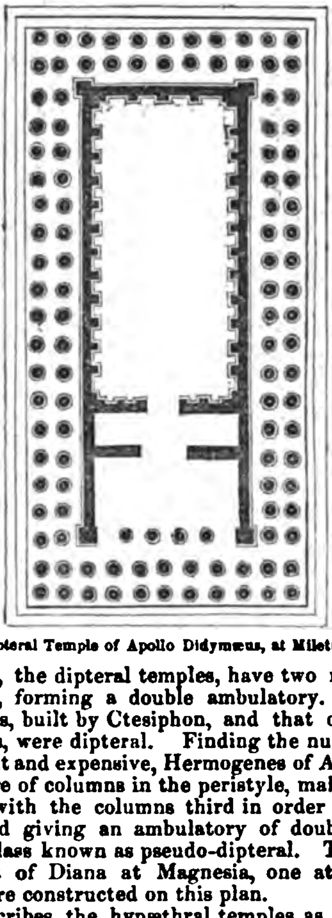
In the year 465 B.C., after the battle of Marathon, Cimon had the remains of Theseus conveyed to Athens, where they were reinterred with great pomp and rejoicing, and this beautiful edifice erected over the place of sepulture. It is hexastyle, but differs from the rule of Vitruvius, who says that where there are six columns in front and rear, there should be eleven in the flanks, including those at the angles. Here, however, there are thirteen columns in the flanks; nor amongst the Greeks does there seem to have been any fixed rule, the number differing according to the required length of the temple. The hexastyle Temple of Apollo Epicurius at Bassæ has fifteen columns along each flank, and that of Bacchus at Teos eleven; but in the latter temple there is merely a cella, with its pronaos, without any apartment in the rear.



Peripteral Temple of Apollo Epicurius, at Bassæ.

The Heroum of Theseus has a cella, with a pronaos and posticus, formed by the prolongation of the side walls of the cella. The cella is 40 feet in length, by 23 feet in breadth; the pronaos, with its portico, is 33 feet; and the posticus 27 feet in depth. The columns are 3 ft. 3·65 in. lower diameter, and 18 ft. 8·6 in. in height; the intercolumniations of the peristyle are 5 ft. 4 in., and the width of the ambulatory 6 feet. The whole height of the temple to the top of the pediment is 33½ feet. The Greeks, in a great measure, overcame the effect of the small space between the portico and the pronaos, and the posticus and the opisthodomus, by making the interior columns of smaller dimensions; thus calling in the delusion of perspective to their aid. The interior of the temple also was raised a step from the portico. The eastern portico only of the Temple of Theseus was adorned with sculpture. The metopes were carved in bas-relief, the subjects taken from the principal events in the life of the hero, and the walls of the cella were decorated with historical paintings by the hand of Mycon. This temple was surrounded by a peribolus, of such extent that the military assemblies were held within it. It was also an asylum, or sanctuary, and is now a place of interment for those of our countrymen who die at Athens.

During the last year of Turkish dominion in Greece, the Pasha having been informed that a hive of bees had settled in the north-eastern corner of the pediment of the Temple of Theseus, ordered his people to bring him the honeycomb. Upon being told that it could not be got at, as it was so far down among the stones, he commanded the corner of the pediment to be thrown down, in order that the honey might be obtained. Such anecdotes should be considered by those who blame the English for having carried away the relics of ancient Greek art—these "robberies," as some have been pleased to call them, having been the only means of preserving them from total destruction.



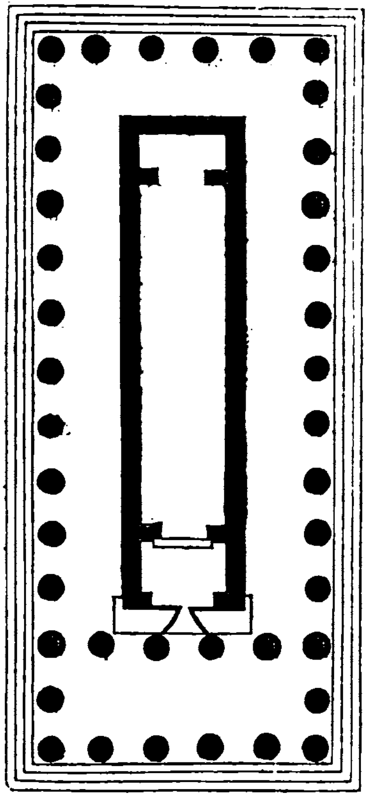
Dipteral Temple of Apollo Didymæus, at Miletus.

The fifth class, the dipteral temples, have two rows of columns along the flanks, forming a double ambulatory. The Temple of Diana at Ephesus, built by Ctesiphon, and that of Apollo Didymæus at Miletus, were dipteral. Finding the number of columns both inconvenient and expensive, Hermogenes of Alabanda omitted the interior range of columns in the peristyle, making the walls of the cella range with the columns third in order from the angles of the front, and giving an ambulatory of double width,—thus inventing that class known as pseudo-dipteral. The great temple at Pæstum, that of Diana at Magnesia, one at Selinunte, and many others, were constructed on this plan.

Vitruvius describes the hypæthral temples as belonging to a different class; but this distinction does not appear to have existed in Greek temples; all those, whether peripteral, dipteral, or pseudo-dipteral, dedicated to the principal divinities, being hypæthral, or having the cella open to the sky. This custom originated in the east, and was continued amongst the Greeks, it being deemed impious to confine the deity within a temple covered in by mortal hands, instead of by the blue canopy of heaven. To exclude the sun's rays, or to protect the statue placed in the cella from the inclemency of the weather, a peplus, or veil, was either extended over the opening in the roof, or suspended before the statue. The peplus is mentioned in a passage of Euripides:—

> "Then from the treas'ry of the god he takes
> The consecrated tap'stry, splendid woof!
> To clothe with grateful shade the wondrous scene,
> First o'er the roof he spreads the skirted peplus."

The preparation of the sacred peplus, which was richly embroidered, was committed to a band of chosen virgins. At Athens, a new peplus was presented to Himeron, at the recurrence of the great Panathenaic festival, every five years.



Pseudo-dipteral Temple at Selinunte.

It at first excites surprise that in countries so limited as Greece and her colonies in Asia Minor, so many magnificent temples should have been erected, regardless of labour and expense, and that some of the most splendid sacred edifices existed in otherwise insignificant cities; but it must be remembered that many of these were cathedral or amphictyonic temples, where people of different states and towns assembled at certain times to celebrate festivals, hear causes argued, and settle disputes; and all thought it a honour to be allowed to contribute to the adornment of the holy edifices. Such were the Temples of Diana at Ephesus (in renewing which Alexander the Great in vain offered to defray the whole expenditure to be permitted to have his name inscribed there) and of Apollo at Delos, where the Ionians were accustomed to congregate at a periodical festival; and where Apollo was worshipped under the ancient form as Mithra; the capitals of the columns being formed each by the busts of two kneeling bulls, side by side, the old symbol of sun or fire worship (an engraving of which is given in the supplementary volume of Stuart's 'Athens'). Such too was the great Temple of Jupiter at Olympia, which was crowded with worshippers from all the Hellenic states every fifth year to celebrate the far-famed Olympic games, to be victorious in which was considered supreme felicity. The Temple of Jupiter was more ancient than the Parthenon, dating, according to Pausanias, as far back as 650 B.C.; but it must have been restored or repaired after that time, as the roof is said to have been constructed on the plan of Byges of Naxos. This temple was of the Doric order, peripteral and hypæthral: it was 230 feet in length, 95 in breadth, and 68 in height to the summit of the pediment: it was built by Lybon of Elis. On the centre acroteria on each pediment, stood a gilt figure of Victory, with a golden shield beneath, and gilt vases were placed on the acroteria at the corners of the roof. According to Pausanias twenty-one shields were suspended on this temple, the spoils of Numonius, on the conquest of Achaia. The custom of hanging shields on the temples has been before remarked upon; one was placed on the Temple of Minerva at Syracuse (probably on the acroteria), which was seen far out at sea: it was the custom of the Sicilian sailors to offer sacrifices to ensure a prosperous voyage on losing sight of this shield. The chief glory of the temple at Olympia was the colossal statue of Jupiter, 60 feet in height, formed of ivory and gold: one of the masterpieces of Phidias. After the works of the Parthenon were completed, Phidias and his disciples removed to Elis to adorn the city of Olympia; he was employed here about four or five years, and was held in such high estimation that he had a studio assigned to him, close to the sacred grove, and was allowed to inscribe his name upon the footstool of the divinity. The building in which he formed the statue was long known as the workshop of Phidias. The god appeared seated upon a throne, crowned with a golden olive wreath; in his right hand he held an image of Victory, and in his left a sceptre richly inlaid and surmounted by the figure of an eagle; his robe and sandals were of gold, covered with lilies and other devices; his throne was sculptured in relief, and set with ivory, ebony, gold, and precious stones. On each foot of the throne were four dancing Victories in relief, and two statues of Victory stood near on each side. So beautiful was this Zeus considered, that according to Arrian, it was a misfortune to die without having seen it. The descendants of the great sculptor had alone the privilege of cleansing and preserving the statue. The whole territory of Elis was sacred to Jupiter; it would have been an act of the greatest impiety to carry on war within its limits; if an army marched through the state, they delivered up their arms on entering, and were only allowed to resume them on passing the boundary.

The oracular temples of Greece also attracted a great concourse of those desirous of prying into the secrets of futurity. Of these the Temple of Apollo at Delphi was the most celebrated; the first stone edifice was erected here 548 B.C., and was the great repository of the treasures of ancient Greece. Whilst Phidias was employed at Olympia, the artists of the ancient, or archaic school, were engaged in decorating the Temple of Apollo. Amongst the followers of this style of art, we hear of Canachus, Calon, and Hegesias; but as the archaic school retained the crude, stiff, traditional forms, whilst Phidias and his pupils effected a revolution in art through their earnest study of the beautiful in nature, it is not wonderful that the names alone of the former artists have descended to posterity, and those attended with but little fame.

The means by which the oracular responses were obtained at Delphi are too well known to need repetition here; but in another celebrated shrine at Argos, the mode of deception has only been discovered since the temple fell into ruins. The end where the altar stood was excavated out of the rock, and the remainder of the building constructed of baked tiles: part of this structure with the altar still remains. Dr. Clarke, in his interesting 'Travels,' relates that he found a subterranean passage leading to the back of the altar; this, he says, was so cunningly contrived, having a small aperture level with the surface of the rock, that it was easily concealed. A person descending into this passage might creep along till he got behind the altar, from whence the voice mysteriously proceeding, would have an imposing effect to the prostrate worshippers in front. The reverberation of the hollow rock would give a supernatural sound to the voice of the person concealed.

A third class of sacred edifices supported by the contributions of the assembled multitude, may here be mentioned—those dedicated to Esculapius, the divine physician. These places of resort for invalids were generally situated near some medicinal spring, and, like our Bath or Cheltenham, appear to have been as much for amusement as for restoration. The sacred grove of Epidaurus was the most celebrated, where the efficacy of the holy stream or the favour of the god was acknowledged by the presentation of numberless little effigies of limbs, or other parts affected, such as may be seen suspended around the image of some miracle-working saint in the Continental churches of the present day. Many of these at Epidaurus were attached with wax to the knees of the statue of Esculapius.

So great a similarity exists amongst the temples of ancient Greece that a detailed description of each would be mere repetition, there are two however, which from their extreme beauty, demand particular notice. I shall begin the next lecture, therefore, with an account of the Parthenon and Erechtheion at Athens; and shall then describe the theatres and other places of public amusement, concluding with the villas of the Greeks, and their mode of decorating their edifices, whether public or domestic.

LIST OF AUTHORITIES.

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TERRACOTTA AND ARTIFICIAL STONE

Some remarks on Terracotta and Artificial Stone as connected with Architecture. By CHARLES FOWLER, V.P.—(Paper read at the Royal Institute of British Architects, June 10th, 1850.)

ALTHOUGH the subject I have to present to you is not of an attractive nature, I hope it may prove not unworthy of your attention, inasmuch as every architect must have experienced the importance of being well acquainted with the various materials which may be available according to local and other circumstances, and which require various modifications of design and construction, demanding the exercise both of his taste and skill. With this impression, I venture to invite your attention to the subject of Terra-Cotta and Artificial Stone, as materials offering valuable means of obtaining architectural effect and expression when stone or marble cannot be procured, or cannot be employed by reason of their great expense. Under the general designation of terra-cotta, in its literal sense, I include all moulded work, such as bricks formed to be substituted for stone in constructing columns, vaulting-ribs, windows, and other architectural members, as well as those parts which are more strictly ornamental, as corbels, tablets, friezes, statues, vases, &c. For these various purposes, and under an infinite variety of circumstances, we shall find that terra-cotta has been employed with good effect; giving the advantages of variety and durability, at a moderate expense, in many cases in which these objects could not be so well attained by any other means. On investigating the origin of terra-cotta, or the practice of moulding and baking clay for building purposes, we may extend our researches to the earliest times; for it is obvious that the art of forming bricks and pottery must have been one of the first efforts of civilisation; but, although such may have been its origin, our subject properly relates to superior efforts, requiring the talent of the artist as well as the skill and dexterity of the artisan.

The ancient cities of Nineveh and Babylon are considered to have been chiefly constructed of brick; but modern researches have not brought to light any specimens that come properly within the scope of our subject. No bas-reliefs, nor architectural members of any kind, in terra-cotta, have been found, but merely vast mounds, the debris of buildings serving only to identify the sites of these once renowned cities; this negative evidence, however, must not be deemed conclusive against the existence of the art in places where so many circumstances concurred to call for, and to promote its practice.

In Greece, where stone and marble abound, and were so extensively used by the ancients in their celebrated structures, we find, nevertheless, that terra-cotta was sometimes introduced—for example, in the eaves of roofs, in which use and ornament were skilfully combined, by making the crown mould of the cornice form the front of the gutter. It is evident that the roofs to which these specimens belonged were covered with tiles, of which they formed the bottom course; thus uniting the roof with the cornice belonging to both, and answering the useful purpose of an eaves gutter. It will be seen that there is considerable ingenuity in the mechanical contrivance for fixing, as well as great taste in forming this crowning member of the cornice. Campana, in his Work on Terra-Cotta, mentions ornaments among the remains of the Erectheum, which are probably similar to that already described.

Many instances might be adduced of the introduction of terra-cotta in Roman temples, but I am not aware of any specimens of the same architectural character as those just mentioned. The collection of bas-reliefs and statuettes, &c., at the British Museum, are well-known (although at present secluded in close presses.) They exhibit striking examples of the taste and skill of the ancients in this department of decorative art. Engravings of them have been published by the Trustees of the Museum, and many of them are further illustrated in a superior manner in Campana's work, from which it appears that there are duplicates of several of the specimens, and consequently that moulds must have been employed in producing them. There are also further repetitions of these specimens in the collection of the Soane Museum. It is remarkable that in every instance clay only is used of various kinds and degrees of fineness, but without any mixture of other materials, as in the modern practice of forming artificial stone. The Etruscans were so eminently distinguished by their skill and taste in the fabrication of pottery that we may naturally infer that they employed the same material in architectural decoration also in lieu of sculpture; but I am not aware of the existence of any specimens of Etruscan terra-cottas, excepting those very rude ones of tombs and monumental effigies in the British Museum. After this cursory glance at the use of terra-cotta by the ancients, we pass on to the use of it in the middle ages of which the evidences are more numerous, as the application was much more extensive.

In Romanesque buildings, and those erected in the cinque-cento period, we find moulded bricks and various architectural members of terra-cotta, such as corbellings, columns, vaulting-ribs, cornices, enriched arches to doorways, windows with mullions and tracery, medallions, tablets, friezes, &c. In the north of Italy, where the country is to so great an extent flat and alluvial, and stone is consequently scarce and dear, there are numerous instances of the use of terra-cotta in churches and other public buildings. Aggos' Tower, and the church of S. Maria delle Grazie, at Milan, may be cited among other examples; the former distinguished by elaborate details executed in moulded bricks, and the latter, in those portions erected by Bramante, containing bas-reliefs and other enrichments in terra-cotta. The more ancient parts have brick mouldings, corbels, &c.

In the north of Germany, the scarcity of building stone has led to a very general use of moulded brick and terra-cotta; and the buildings of the middle ages in these parts are remarkable for the bold and effective manner in which nearly all the architectural features are so executed, and for which we are accustomed to consider stone as almost indispensable. In the churches, which are generally of vast dimensions, there are massive columns elaborately moulded, bold projecting-ribs in the vaulting, mullions and tracery in the windows, doorways enriched with shafts and mouldings—ornamental corbellings, pinnacles, and even finials, all formed in plastic clay well burnt.

At Lubeck the examples are numerous and striking, and besides the churches, which are on a large scale and of a bold style, may be noticed the Rath-haus, the Hospital, and the City gates; the latter being surmounted by towers and chambers of an elaborate character. The domestic architecture is also distinguished by the prevalence of the same style, and produces a very picturesque effect.

At Hamburgh, the church of St. Peter, which was nearly destroyed by the great conflagration in 1842, has been entirely restored, excepting the tower, by Mons. de Chateuneuf, with strict adherence to its original style; the restoration is executed in moulded brick, and is probably the only instance of a modern work of this kind in which that material has been so extensively and efficiently employed.

At Hanover, the Rath-haus is a curious specimen of elaborate mediæval work in brick, but the style is not so general in that city as at Brandenburg, Luneburg, Tangermunde, and other towns lying more to the north and east, which are more completely within the district where brick constructions prevail, and stone is rarely met with in ancient structures. In our own country the art and practice appear to have been introduced much later, and can scarcely be traced beyond the Tudor period, when plastic materials were found particularly convenient and economical in the execution of elaborate details with extensive repetitions of the same parts, as in ornamental chimney-shafts, battlements, corbels, friezes, mouldings, pinnacles, &c. Examples of these are too numerous to be particularised, as they would form a long catalogue of ancient mansions and collegiate buildings by which the age of the Tudors is distinguished, and which have been ably illustrated by the publications of modern authors and artists.

In the parsonage house at Great Snoring the frieze consists of a series of heads in niches, in bold relief, all formed by two moulds, and closely resembling similar friezes in private dwellings at Bologna, where the same kind of ornament is found to prevail. At Hampton Court, the medallions containing Roman heads, in bold relief, inserted in the walls, appear to be of Italian workmanship, and there were several of the same description in old houses in the city of London, but the besom of modern improvement has swept away the greater part of them. The county of Norfolk is remarkable for a great number of ancient structures, in which the architectural and decorative features are wrought out in moulded brick, or terra cotta (doubtless for the local reason before alluded to) and amongst the most ancient of these may be mentioned Caister Castle, near Yarmouth (temp. Hen. VII.) whose lofty towers and bold corbellings make it assimilate with some of the ancient fortresses on the banks of the Rhine.

The style of execution which we have been considering appears to have had its full development during the Tudor period, at the latter part of which it was superseded by the introduction of Italian architecture; for examples of moulded brick work, or terra cotta, are rarely to be met with in edifices erected subsequent to the reign of James I., except as detached tablets, shields, or heraldic insignia.

It is rather remarkable that the revival of the manufacture of terra cotta, or more properly of artificial stone, in England, should have been effected by a lady. About sixty years ago, Miss Coade, from Lyme Regis, possessing a large share of scientific knowledge and energy, embarked in a small manufactory of artificial stone in Lambeth, which, by her perseverance and good management, eventually attained a considerable degree of celebrity. To this original establishment in Lambeth the merit is due of greatly improving the composition of the material, and the processes by which its permanent character was attained. The proprietor had also sufficient enterprise and discrimination to avail herself of the talents of some distinguished artists, and thus produced works of a superior character, which may fairly vie with those of the chisel. The bas-relief in the pediment over the western portico at Greenwich Hospital, representing the Death of Nelson, was designed by West, and executed by Bacon and Panzetta, who also modelled many other distinguished works.

With respect to modern instances of the use of artificial stone, St. Pancras Church may be considered as one of the most important; the greater part of the ornamental details being formed of this material, at the large outlay of 5400*l*. The work was executed by Mr. Rossi, from the designs of Mr. Inwood, the architect: and, according to present appearances, the material promises to be very durable. About the same time extensive bas-reliefs, colossal figures, and other decorations, executed in the same material, were placed on the front of the Custom House, London, but these specimens have been removed. The statue of Britannia, made of artificial stone, which crowns the Nelson column at Yarmouth, remains uninjured by the exposure, to which the stone work seems to be yielding. The Bau-Akademia, in Berlin, by Schinkel, is a remarkable example of the modern adaptation of moulded brick and terra-cotta, of which every part, even the face of the walls, is most carefully wrought and finished.

Having taken a general view of the history of the art in question, and its application in various ages and countries, it may be proper to give some account of the composition and modes of forming and perfecting the artificial stone as now practised. It has been already stated that the ancient examples are evidently formed simply of fine clay, or brick earth—carefully prepared and well burnt—and they are, therefore, precisely of the same nature as coarse pottery ware, and are correctly designated "Terra-cotta;" but the modern artificial stone is a very different substance, and greatly superior to them in hardness, texture, and colour. The result of inquiry at several establishments shows that some difference exists, both in the composition and processes adopted by the respective manufacturers, but without any obvious difference in the results. The principal ingredient is the white potter's clay, forming about one-half; pulverised stone ware from one-third to one-fifth; ditto glass, from one-fourth to one-ninth; and some add, for finer purposes, a small portion of white Ryegate sand and powdered flint, about one-tenth part of each: these ingredients are carefully mixed in a pug-mill to a stiff consistence suitable for modelling or moulding, and then worked into the various forms required. With a view to ensure perfect burning, an uniform thickness must be preserved in all parts, usually about 1¼-inch, but proportionate to the bulk and strength required; considerable attention is necessary in the process of drying that it should be slow and regular, so as to avoid any distortion of form; the time to be allowed must, in some measure, be governed by the state of the atmosphere and other circumstances. The same considerations regulate the burning, which should proceed by very slow degrees to a white heat, and ample time should be allowed for cooling: the practice in these respects—which appears to vary very widely in different manufactories—allows from ten to fourteen days for drying, from seven to fourteen for burning, and three or four days for cooling.

The kiln at Messrs. W. Cubitt and Co.'s, which may be taken as an ordinary example, is a cylinder of 10ft. 6in. diameter externally, and 10 feet high to the base of the cone. The enclosing wall is two bricks thick, having a large opening for packing and unpacking the articles to be burnt. When the kiln is filled, this is closed up with lumps, preparatory to lighting the furnaces. The interior is lined with tiles ½-inch thick, grooved and tongued together, and set in Stourbridge clay, leaving a vacancy of 4 inches, which is called the muffling, all round. There are two furnaces, and about three tons of coals (Hartley's) are consumed in one burning. The progress of the burning is ascertained by looking through an inspection-hole with a lens in the side of the kiln.

Having been led to the consideration of this subject with a view to its practical application, I venture to adduce some instances in which I have used artificial stone, combined with other materials, in the construction of cornices, which, at the same time, serve the purpose of eaves gutters. The advantages proposed in these cases were lightness and strength, with durability and economy. In one example here exhibited, it will be seen that, as a mere corona of the cornice, it gives apparent magnitude to the elevation, with very slight addition of substance or weight. The material, from its hardness and imperishability, is best suited to the situation where it is most exposed to injuries. It also forms a rim, or margin, which throws back the water instead of allowing it to run down over the face of the mouldings in the usual way, in which the top slopes outwards; and by which, in a smoky atmosphere, the cornice is liable to be much defaced and injured. Another example refers to the cornice of a pediment, therefore it is independent of any gutter. In another example the gutter is at the back of the cornice, and is of a distinct construction. In another the gutter is contained within the facia and crown mould, forming a continued trough, resting on a course of slate slabs, which constitute the soffit of the cornice. And, in the last example, the gutter forms a separate portion, lapping over a facia, which is also of artificial stone; and the whole is supported on slate slabs, as the preceding one. The several parts are united lengthwise, by rebated joints, set in white lead, and bedded in cement on the brick and slate. The Greek examples, before alluded to, first led me to this practical application of terra-cotta. It should be observed, that the chief difficulty in preparing this material for the several purposes mentioned, is its liability to become distorted in drying and burning. To avoid this it is necessary that the pieces should be short in proportion to their width; and then the deflections (which in some degree are unavoidable) may be so adjusted in setting as not to be conspicuous; and as the cornice is the part most remote from inspection, the imperfection is the less observable. Further, it may be presumed, that if the use of artificial stone were more general, and occasioned consequently a greater demand for this description of work, some means would no doubt be found for rendering the manufacture more perfect. In order to obtain a fall or current in the trough gutters, the bottoms are partially filled up with Portland cement having the greatest thickness towards the centre, and gradually diminished to the outlets. This, besides facilitating the discharge of the rain water, serves to strengthen the construction, by covering the joints and fortifying the sides. The colour of artificial stone assimilates tolerably well with Portland or Caen stone, but the texture is liable to have too much of the glare of pottery. Its durability, if properly manufactured, may be deemed almost unlimited, and its economy, if judiciously applied, is a further recommendation; but this involves many important considerations for the judgment and discretion of the architect.

Although these remarks have properly been limited to terra-cotta and artificial stone, which, as the designation of the first implies, have to undergo the action of fire; yet, as the latter is now applied to a material prepared by a different process, it may not be irrelevant to make some mention of it on the present occasion. It appears that this substance consists of a concrete, formed with cement and sand, variously proportioned, and the forms are produced from moulds; consequently one of its chief advantages is economy where numerous repetitions are required. If a nice finish is desired, these productions can be worked up and sharpened by the chisel.

This art has been practised for about twenty years; but it is more particularly within the last ten years that it has been brought into very extensive use: the experience, therefore, of its durability is, at present, rather limited; but, at all events, great credit is due to the manufacturers, for the taste evinced in many of their productions, which constitute another resource, in cases where the works of the sculptor would be excluded by their great expense.

Reverting to terra-cotta, I beg, in conclusion, to observe, that it may be seen from what has been stated, that it possesses many valuable qualities and recommendations when introduced with skill and discrimination—viz., strength, durability, and economy; more particularly where high relief and sharpness are required, and for parts extensively repeated. That it affords the most perfect opportunity for the development of artistic talent in the higher branches of art, inasmuch as the model in this case becomes the original and permanent work; embodying in all its freshness the original touch and conception of the artist. Further, and in regard to structural considerations, that it may be combined with other materials, so as to afford increased means and facilities for giving architectural expression with sound construction and economy.

THE POETRY OF ARCHITECTURE.

A paper read by James Edmeston, jun., *at the General Meeting of the Architectural Association, May 31st,* 1850.

If it be true that Architecture is a fine art; that it is eminently capable of receiving the marks and impressions of mind and intellect; if it has the power of reflecting the radiations of the heaven-born fire of genius—why, then, it is most truly poetical. For what is poetry but a combination of all these? and to talk of the poetry of architecture is not a mere form of unmeaning words, but expresses a fact that should attract our attention and study, since it cannot be possible for us to place the standard of our art too high, or to fix a limit to the excellencies of which it may be capable.

That architecture does possess all these characteristics, I think few will deny; and if to some, such expressions may seem to belong to mere theory, I will ask them, at all events, to allow what is, unfortunately, evident enough—that the opposite of these things exists; that is to say, that want of harmony, that bad taste, which we commonly call vulgarity, and which is the offspring of an uneducated mind and low order of imagination. If, then, it is too certain that architectural forms have the power of conveying to the mind such impressions as these, I must contend that it is absurd and impossible to say that improvement is not to be made. The mind instinctively points out what is vulgar, deformed, and unpoetic: there must of necessity be the reverse of all this, and the mind will discern and approve what is beautiful, poetic, and proportionate.

It does appear to me that more profit than may be at first sight apparent, may be derived from the study of the art under such an aspect as that now under consideration, since the desire of excellence is the incentive to all exertion; and the more fully the mind is impressed with the glorious height and perfection which may be attained, the more firmly and determinately will it buckle on the armour of thought to the task, the more intently will it labour to surmount the difficulties of the road, and gaze firmly on the goal which it desires to reach,—while without faith in the result of our exertions we can achieve nothing.

What I would call the true poetry of the art is that combination of mass, that disposition of outline, that moulding of form and arrangement of detail, which should be guided by taste the most elevated and refined, and, above all, should speak to the beholder clearly and intelligibly, with a voice mighty yet inward—a work, the contemplation of which, like the divine strains of melodious music, should elevate and purify the mind, encouraging those sensations of the soul which partake least of the earthly clay from which we have sprung, but which, with purity and intensity, yield charms to the imagination far beyond those of a grosser nature; appealing to the sensibility of the soul, and to those innate perceptions of the beautiful which God has implanted in all his intelligent creatures,—the external harmony from without, finding an internal response within us. Very mysterious and subtle are these influences of what we call "*the beautiful*," or, as I have called their highest expression, the poetry of art and nature—neither to my mind existing only in the power of perception, but an actuality in the thing perceived; not wholly a matter of the intellect (to be merely acquired like scholastic learning), though certainly to be cultivated and improved,—but partaking of all these; consisting of none wholly, but in part of all; an absolute outward principle, fact, and perfection, existing in and pervading all things, though often we may not perceive or understand it. Yet it is of great importance that we should believe it is to be achieved and evolved; for if not, we may fall into that frigid and philosophic view of our art, which will so alter its nature, that we shall no longer be able to talk of its poetry; and may at last reduce it to a mere manufacture, or to be worked out like a mathematical problem—not taught to spring into warm life by the creative power of genius, full of powerful thought, and clothed with the glowing expressions of poetry. We should, then, gladly welcome those refining influences of high art, allowing that such things may be and are, and strive to improve them to the uttermost. I have not alluded to *colour* as being a primary agent in producing these effects, because I certainly think that, although an important element and not to be despised, yet that it is certainly altogether secondary to form, arrangement, &c.

All fine art must be poetic; for is it not the illuminating power of genius, and the thoughtful ardour of a superior mind, which, working upon the natural rough and intractable material, makes of the block of unshapen stone an Apollo Belvidere, or arranges colours with true and powerful harmony on the canvas? Perhaps it may not be an inapt simile to compare the works of the painter and sculptor to the sonnet, every word of which should contain the richest imagery and most suggestive thought, polished and refined with the greatest care, and yet brought into so small a compass; while the architect's works come more nearly to the grand, less-minutely finished, but powerful and majestic, epic—in part forcible and striking, in part subdued and general; varying in description, but as a whole, grand and complete.

Let us, however, endeavour to trace the poetical element in the old world efforts of architectural art. To begin with the half-temple, half-palace, erections of the Egyptians—the great temple of Karnac, for example; this, and most of the other productions of Egyptian art, do not, I think, bear evidence that the artist was actuated so much by higher impulses, as by the desire to produce something *grandiose* and magnificent: as if each dynasty wished to leave the page of its history indelibly written, and set up on the face of the land for succeeding ages to wonder at, rather than moved by any deep religious feeling, or any of those higher aims which would have ensured more perfect results. Wonderful, majestic, and surprising as are their works, I do not consider that they exhibit so much mental vigour as perhaps every other style, nor much elegance of mind; in fine, I think that if the Egyptians had taken a higher aim, and been actuated by higher purposes, they would then have produced, with their wonderful technical ability and resources, works of a higher stamp, and in all respects much superior: but they seem to have been wanting in imagination, and, from some circumstances of position or habit, to have been deficient to some extent in *poetical* genius—learned and scientific though they certainly were.

But leaving this era of art, and turning to the Greek—what an extraordinary difference do we find! The characteristics and purposes of the former style are quite gone (I do not mean mere evidences of relationship and descent, but of feeling and thought); and I think that it must be allowed that here the poetical element exists most strongly. In Grecian buildings we see the language of mind, earnest, determined, elevated, and poetical—a purity of thought and loftiness of idea which is the more surprising when we consider the grossness of their religious myths and other circumstances of their position. Let us suppose the Parthenon as it was first erected, fresh and unmutilated—from its vastness, imposing and arresting the attention of the beholder; with its just proportions, pleasing and delighting his eye; and with its general purity of design, refining and elevating the emotions of his soul: exciting no one thought displeasing and gross, but leaving him better and happier—he can scarcely tell you why—for having seen it. Yet the reason is no more than this, and as we have before observed, that genius and thought *can* make themselves felt and evident, and can speak to the minds of others, no matter through what medium—imparting a feeling which language can hardly express, but which the soul can well understand; even as the poet will carry away his hearers or readers by the creations of his fancy conveyed in words.

Coming next to Roman art; I think we find the poetical element much less clearly expressed. The reason I take to be, that the Romans had naturally no such soul-felt love for their art as the Greeks had; their time and attention were too much otherwise occupied; they wanted, to a great extent, that elegance of mind which the Greeks possessed; and their fondness for military pomp and grandeur, and for outward show, made itself apparent and over-ruling in their architecture: for to do much and largely seems rather to have been their aim than to do well thoughtfully and carefully. They seem to me much more the works of a great nation than of a refined one; and therefore, as we have argued must be the case, to possess much less poetic feeling and poetic influence, in spite of the grand proportions of a Colosseum, or the enrichments of a temple to Jupiter Tonans.

The creations of the modern Italian school, great and wonderful as they many of them are, still suffer from the errors of their parentage; and are, generally speaking, certainly wanting in those higher attributes to which we at first alluded, notwithstanding all the bright names which adorn the list of masters, and the many works which they have left behind them worthy of our respect and admiration. Yet, perhaps I ought to except in some degree the minor productions of some of the masters of this school—the loveliness exhibited in the beautiful gardens, where fount and bridge, temple and loggia, under the clear blue sky and amidst Italian foliage, speak visions of love and romance, and produce an imaginative world in harmony with itself.

In the Romanesque we find a certain rudeness of invention, yet fervour of thought and boldness of fancy, full of great merits. This style would appear the production of a society struggling under many disadvantages, yet ruggedly bent on escaping from deteriorating influences, and on writing its name and destiny in characters of its own: not to be imitated or copied in detail—certainly not to be despised, but to be respected for its truthfulness and earnestness, and honoured for its spirit. I need only mention the churches of Pavia, Verona, Lucca, Pisa, &c., to recal to your recollection the masterly and vigorous characteristics of this style; they all bear the impress of a certain freeness of idea, which is certainly poetry, though not of the first order.

To pass over these periods of art however, thus lightly touched upon, let us look at the Mediæval styles—I mean all of those usually called Gothic: but as time and space confine us to a short limit, I wish to regard merely that of our own country.

In the Saxon examples, the art must have been at so low an ebb, that it would be fruitless to expect any of the higher expressions. In the Norman, we find an evident and increasing improvement, with, I think, much of the same feeling as the early Romanesque—instance Norwich Cathedral—which becomes greater and greater in the transition, till we arrive at the well-developed Early English; a change gradual, yet rapid, and every way marvellous. And here, I think, we may trace the evidences of a spirit and genius which, considering the state of society, the iron-bound darkness of the age, and the heavy curtain of ignorance that hung over the land, comes most surprisingly near in spirit and perfection to the Greek—an assertion which, to some, may appear bold and untenable; yet, let us consider carefully the beautiful proportions of some of the specimens of that style which still remain to us, the purity of invention, the graceful combinations, the pure style of ornament in the foliations, the play of light and shade in the deep undercut mouldings: the whole truthful, fine in conception, and most suitable to its purposes. And in calling all this to mind, let us suppose a cathedral as entire and complete; not with the admixture of other styles or periods, as we now see it, but of a piece from turret to crypt;—and will any one deny that such a building gives evidences of the highest poetic spirit, and must strike a beholder even as we have contended such a building should and must do? There are some, perhaps, who will say, "Very fine, truly, your gargoyles, grotesque, and sometimes indecent groups and figures, &c." To such I should reply, that these are but the greater proofs of my position: what are they more than the evidences of that state of society which renders the contrast of general perfection in the art so much the more to be wondered at; what more than the weeds here and there pressing through, but unable so to choke the soil as to interfere, except so slightly, with the plant which has grown up on its surface to beauty and grandeur, notwithstanding and in spite of all. Consider all this, and I think it may fairly be allowed that this phase of English art is not so far behind the lofty standard of the Greek. Let me be understood *not* to say that this period of English art is to be put side by side, and in the same parallel, with the Greek—but that it is much of the same spirit and order; and, in other words, that if the outward social influences had been the same, there is much to show that English architects could have achieved even what the Greek architects did;—and if so, then why not again now?

I cannot allow that it is by association that we admire this style so much as some people would have us think. It may certainly have some influence; but if it were wanting, I do not think we should admire the less. Association and habit may lead us to overlook and bear with what is faulty, but can never create beauties unless they actually exist. Nor do I see wholly the force of the notion that the Greek has the more intellectual expression, the other the more spiritual; least of all would I exalt the one at the expense of the other, and impart a false colouring by such empty jargon, thus applied, as Pagan and Christian. Every superior effort of genius is spiritual and intellectual—both, if directed rightly; and without doubt the class of mind and spirit was the same in both cases, although in the one sadly clogged and trammelled by outward influences. And I do think that this era of English art was infused strongly with what we have called its *poetry*; and it is a matter of great regret that it should have rested so short a time at this point. With surprise we see the rapid transition to the geometric period, which, had it been continued under those mental influences that governed the development of the Early English, would, I think, most likely have surpassed it—since the prevailing ideal was as pure, while the scope for design was more extended. Yet, alas! strange as it may seem, the cunning and wise spirit of the first inventors seems gradually to have left their successors, and to have become extinct; till in the Perpendicular it became less strong, and in the later periods of that style still less and less, till at last it became utterly debased and lost. This was sad: but it was a worse blow for high art when the revival styles were introduced; this shut off the connection with the past entirely, and what had been done previously became quite lost and forgotten; and although no man of genius can touch anything without making his mind and talent felt and acknowledged, yet not to call it *impossible*, he can hardly succeed in infusing the highest spirit into his works if he is forced to walk on the line chalked out for him, instead of choosing the path he would desire to travel. A Thorpe could do good things in a bad cause, yet in the revival styles generally, I confess I cannot discover (except with a few exceptions) that poetic spirit of which we have been speaking. Although a Wren erected a St. Paul's, which is one of the wonders of the world, we cannot but feel, I think, the falling off, and what it might have been otherwise the case; but while we do so, let us humbly do homage to the great genius which, under such circumstances, could do so well and magnificently, and deplore the arbitrary laws of fashion and public opinion that placed him in such a position: who was truly a poet and artist of the first order, and has left works which are indeed strongly imbued with that spirit and feeling which forms our subject. I have said that we have had architects among us whose treatment and governing tone of thought have been of the same order, and of as high an aspiration, as those of the Greek period; while certainly our architects of the revival school have shown themselves at least equal to any of those of the Palladian era; and nothing shall make me believe that in this day we have not men among us equal for brilliancy of thought and purity of taste to any that ever lived. The tone of society is higher, loftier influences are at work, than existed in the time of the ancient Greeks; and if things as great and beautiful do not come to pass, let the nation look for the cause in itself—in its arbitrary demands and own choosing—in its refusal to encourage those whose life is devoted to the study of the art—in its cruel fashion which has made a false state of things almost necessary—and as much in the mercenary spirit which governs all its actions: when the truth is, that high art can never be bought at too high a price, or its kindly influences valued too dearly.

It is probable that the present fashion of reverting to the mediæval styles for one branch of the art is not without its good effects; if we may only be led by it to search patiently for and find the lost thread which will guide us to excellence and improvement—that is, to seize the spirit and work it out—not be content with the form; and if we will only determine to scorn the quack prescriptions and abominable inculcations of a Cambridge Camden Society. We may expect to retrograde, indeed, if we are never to get beyond the school-boy work of merely copying what is put before us; nay, more, to ensure that nothing may be wrong, I believe, in some cases, one church has been transplanted by the exact copying of stone for stone, and moulding for moulding, to some distant situation, most likely very unsuitable for the design. What sad folly is this—what exquisite contempt does it heap on the architects of this generation.

A better and more inquiring spirit is, however, abroad; let us all hope that the system and faults we condemn will gradually be broken through and overcome. Above all, let us not despair; for as I remarked at the outset, the higher the aim, the more satisfactory must be the result of our efforts. Even though we fall far short of what we could wish, one thing is evident—that no man can be great when he studies only to be little.

MILITARY ARCHITECTURE OF GREAT BRITAIN.

On the Military Architecture of Great Britain. By the Rev. C. H. HARTSHORNE.—(Paper read at the Royal Institute of British Architects, May 6th, 1850.)

MR. HARTSHORNE commenced by observing:—When I acceded to the request that I should offer you a few remarks upon the Military Architecture of the Edwardian Age, I did not sufficiently consider that my own researches had been of a desultory nature, and that they would necessarily want that practical illustration which the subject can only receive from those who make the science of architecture their constant study. Nor did I recollect that the branch of it to which I had turned the greater part of my attention, was one that had lain in comparative neglect by the profession, under an idea that it offers little deserving of imitation in modern buildings, and therefore that I should have to conciliate in some degree the comparative disfavour with which it has been generally regarded. Yet I have been encouraged, under the hope that having endeavoured to throw some fresh light upon a dark portion of Architectural history, the facts I have brought together might add something to our limited knowledge of Pyrgology. Having carefully measured these different buildings, whose plans now hang on the walls (for without having applied the two-foot rule, and five-feet rods, I feel convinced that no remarks would be entitled to the least consideration,) having examined them in analogy with the respective systems of fortification peculiar to the period, and in detailed connection with each other, and subsequently consulted those evidences stored up among the national records which serve to disclose the circumstances and the cost of their erection, I thought, as we have all a common object in view, I might venture to lay before you the conclusions to which they have given rise. But I undertake this agreeable office, not influenced by the supposition of instructing so many from whom I ought to learn, but rather with the view of simply stating the results which this combined method of illustration has originated in my own mind. The announcement has, perhaps, been made public in too extended and general terms, for a discussion of the Military Architecture of Great Britain would occupy more time than the Institute might feel justified, even under more competent guidance, in bestowing upon it; and I will therefore, for present convenience, confine the attention to those leading features which the subject presents under the Norman and Edwardian periods. Passing over the numerous earthworks thrown up by the Britons against the Roman invaders, fortifications which, especially on the North Welsh borders, excite our astonishment for their magnitude and strength; and, disregarding those carefully built walls, which the conquerors subsequently erected to preserve their newly-acquired possessions, I will come at once to a time when there is direct evidence to show the precise date, the methods adopted, and the charge of building, some of the most important English and Welsh Castles. Of the Conqueror's castles, we know little more than what we read in 'Domesday,' which is simply that of the forty-nine enumerated in his survey, he built eight himself, and the rest were erected by his barons. Our only true source of information concerning them are the official documents of the time; and, after the great survey, we have a break in the series of records till we come to the Sheriffs' accounts.

Mr. Hartshorne then proceeded to explain the nature and importance of the official documents still existing, and known as the Pipe Rolls, the Clause Rolls, the Liberati, the Patent, and the Minister or Chamberlain's Accounts, all of which are kept in regnal years. The following may serve to illustrate the value of the information to be obtained from examination of these documents. From the Pipe Rolls we learn the dates, as well as the cost of construction, of different portions of the castles described in them :—

				£	s.	d.
	Bridgenorth. *The Tower.*					
Temp. 15, 17 Hen. II.		A.D. 1167—1172	cost	26	4	1
.. 28 Hen. II.	Repaired	1182	..	2	16	8
.. 8 Rich. I.	Repaired at base	1196	..	8	5	0
.. 8 John	Repaired	1206	..	10	0	0
	Dover. *Turris.*					
.. 30, 31, 32, 33 Hen. II.		1184—1187	..	797	10	2
	The Cingulum built 1186. Mauricius Ingeniator.					
	Colchester.					
.. 26 Hen. II	Turris repaired	1180	..	10	8	8
.. 6 John	Repaired					
	Porcinus Ingeniator.					
	Berkhampstead.					
.. 6 Hen. II.	Works on castle (& ingeniator 48s.)	1160	..	43	6	8
	Kington.					
.. 33 Hen. II.	Repairs of palisades	1187	..	0	5	0
	Cambridge.					
.. 19 Hen. II.	Works on castle	1173	..	31	0	0
	Bedford.					
.. 29 Hen. II.	Castle repaired	1183	..	12	0	0
	Scarboro'.					
.. 7 to 15 Hen. II.	Castle and keep	1161—1169	..			
	Orford.					
.. 12 Hen. II.	Commenced	1165	..	323	0	0
.. 19 Hen. II.	Fosse	1173	.. total	433	1	9
.. 34 Hen. II.	Tower repaired		..	10	12	0
	Hastings.					
.. 18 Hen. II.	Drawing stone for the turris	1172	..			
	Arundel.					
.. 33 Hen. II.	Flooring the turris, and for making a berbary before the King's chamber	1187	..	12	13	4
	Bogis.					
Temp. 18 & 19 Hen. II.		A.D. 1172—1173	cost	394	6	0
.. 34 Hen. II.	Finished		.. total	397	16	0
	Nottingham.					
.. 17 Hen. II.		1171	..	274	14	9
.. 31 Hen. II.	Baly completed.					

Mr. Hartshorne then explained, referring at the same time to the plans and drawings on the walls, the parts and appendages of a castle, their uses, and relative positions, viz.:—The Keep—the Fosse—the Barbican—the Portcullis—Stockade—Enceinte, or Cingulum—the Baly—Donjon—Loops—Oillets—Cross Oillets—Battlements—Crenelles—Embrasures—Merlons—Alures—Vawmer—Postern Gate; or Sally Port—Drawbridge; or Pons tornatilis—Gemews—Bastions—Towers—Turrets—Machicolations—False Machicolations. He next alluded, in further explanation of the subject, to the instructive and magnificent pile of Caerphilly, with its leaning tower, 9 feet out of perpendicular, and to Bridgnorth Castle, whose ruined tower inclines some 25 feet, and bears evident marks of reparations at its base having been made at different periods.

The names and duties of the officers attached to a castle were then described—viz., the Constable; the Ingeniator; the Attiliator; the Garritor, or Sentry; the Porter; and the Watchman, for whose shelter shutters were contrived in the embrasures of his watch turret. As Engineers, mention was made of Alnod, at the Tower, temp. 20 Hen. II., 1174; Yoo, at Windsor; Bayard, Nottingham, 7 John; Ganfridus, at the Tower, 37 Hen. I.; Albert and Urric, Hen III.; Richard, Edw. I.

A succinct description of Norman castles followed, in which it was stated, that they were generally built after the same model, and that they have usually a keep, or square building, on a mound or elevated portion of ground. A remarkable feature of the keep is, that the *entrance is on the first floor*. The walls are strengthened at the sides by shallow buttresses, which die into the face of the work before they reach the summit. The earliest have no portcullis. They were *defended by outer walls*, of the circle of which they sometimes form a part, as Pevensey.

The keeps are of various shapes, the quadrangular form being the most common; as at Rochester, Porchester, Canterbury, Rising, Heddingham, Norwich, Newcastle. Sometimes they are of polygonal shape, as at Kilpeck, Caerdiff, Coningsboro' Chillham, and Orford. At others, they are circular, as at Skenfrith, Pickering, and Launceston, to which class may be assigned Alnwick. The solid type of the Norman keep passed, by an easy gradation, into the geometrical form, as seen in Clifford's Tower at York, and later again at Barnswell, 1264, Hen. III. The transition from this to the concentricity of the Edwardian, was natural and easy. Of the Norman and Edwardian forms, all later ones are only modifications.

To illustrate the gradual progress which took place in building these castles, attention was called to the Castle of Alnwick, in Northumberland, which was commenced by Yoo de Vesci, temp. Hen. I. William de Vesci, 26 Edw. I., having no legal issue, enfeoffed it to that great prelate, Anthony Bek, Bishop of Durham, in social confidence that he should hold them for William de Vesci, his illegitimate son, till he came of age. But being irritated by some slanderous words he had spoken, he afterwards sold the castle, 19th Nov. 1309 (3 Edw. II.) to Henry de Percy. He made large bequests to Fountains' Abbey, where he was buried before the high altar, dying in the 8 Edw. II. His son Henry, who succeeded him, built the octagonal towers of entrance into the inner baly, about the year 1350, as is shown by the armorial bearings of the Nevilles, Fitzwalters, and Umfruanville, inscribed on shields under the battlements. This castle was visited by King John, Edw. I., Edw. II., and William, king of Scotland, was taken prisoner under the walls in 1174.

The remaining portion of the paper had reference to the Edwardian Castles of Wales, and consisted chiefly of a detailed account of the progress of the works at Conway and Caernarvon, being the result of a very long and diligent research, among the records before alluded to, in connection with a careful examination, measurement, and delineation of those buildings. Mr. Hartshorne demonstrated that the works were commenced at Caernarvon, 10th November 12 Edw. I. (1284), six weeks after the execution of Prince David, at Shrewsbury; and at Conway, 28th October, 11 Edw. I. (1283), thus showing that the latter castle preceded the former by a few months in the date of its erection; and that the walls round the town of Caernarvon were built in the 14th year (1286), when some portion of the castle was covered in with lead, and the works were in progress in the fosse. That in the same year the castle at Harlech was begun, and that at Criccaeth repaired. That the works at Caernarvon were in progress, 19 Edw. I. (1291) That little had been done besides the town walls and the fosse round the future castle, when Edw. I. visited the town, for the first time, 1st April, 1284. That his son, the Prince of Wales, was born there on the 25th of the same month, but by no possibility in the Eagle Tower, as usually asserted. That after little progress in the 19th and 21st years, what had been erected was rendered useless by Madoc's insurrection, in the 23rd year (1295), and the works were begun anew from the north-east angle, and thence along the southern side. That the records and the change in the masonry showed the north side to be of different ages—the earliest some time between 23 and 29 Edw. I. That the Eagle Tower was the work of Edw. II., as shown by records expressly relating to its erection, and by the form and character of its mouldings. That it was roofed in the month of November, 1316; floored in February, 1317; and the eagle was placed on the battlement the first week of March. That the upper portion of the north side of the castle, entrance-gate, &c., were finished 13 Edw. II (1320), and the royal effigy fixed there the last week of April, in the same year.

This detailed statement of the progress of the works entirely controverted the general opinion, that Caernarvon Castle was constructed in the short space of twelve months, and proved that the present buildings were the labour of 38 years, and being carried on from 1284 to 1322, even extended into two reigns. The early progress of Conway was traced in a similar manner, and an account was also given of the actual state of the thirteen royal castles in North and South Wales, 17 Edw. III. (1343), which had been granted by him to his son, the Black Prince, when a large sum was estimated to be required for repairs, nearly half of which was essential for the castles of North Wales.

Many of the extracts from the calendars, expense rolls, and other documents, quoted in the course of the paper, were highly interesting, from the precise way in which they exhibited the industrial economy of the time, the rate of wages, the price of material, and the method of carrying on large works; and the paper itself was illustrated by several plans and drawings of a large size.

Mr. Hartshorne having concluded his paper, Mr. Cockerell, the Chairman, said—"All present will, I am sure, join gladly in returning thanks to the Rev. Mr. Hartshorne, for the very luminous discourse he has given us on the Castles of Great Britain, and more especially on those of the time of the two first Edwards. To a great country, rich in historical associations, such a subject must, at all times, be deeply interesting, and it is one well worthy the consideration of the antiquary and the historian, as illustrating a portion of our national architecture. It is, moreover, especially interesting to us, as revealing the relative state of the art of building, and of our own profession in those early times, as well as the rate of wages, and the condition of the working community. We are greatly indebted to our reverend friend for investigating the very minute and authentic resources which he has opened to us; and in expressing our obligations to him, permit me to say, that I do not know which to admire most, the elegance, or the perspicuity with which he has presented to us this curious lore, which tends in so remarkable a degree to illustrate the state and position of our art in the middle ages."

Mr. Donaldson: "The Institute is much indebted to our reverend friend, for making its members acquainted with these remarkable documents, relating to the construction of this interesting group of castles. That no body of men could, I believe, appreciate better than this body, the importance of the information he has placed before us, will, I think be acknowledged when I state, that about ten years ago, the Institute offered its medal for the best restoration of an ancient castle, and that we possess a very skilful set of plans representing the castle of Sheriff Hutton, designed by Mr. Sharp, jun., then of York, and accompanied by a learned dissertation upon the relation the different parts of the castle bear to each other. The reverend gentleman, admirable as was his paper, has stopped short on the threshold. He has given us the dates and cost, and its progressive development; but it would be still more interesting, if possible, were he to give us an account of the connection of the different parts of the castle, with the reference they bear to each other, and the reasons for the differences which exist between them—why one tower should project more than another—why some should be polygonal, some round, and some of complex configurations—why, in short, there should be such differences under similar circumstances as those apparent in the examples now displayed on our wall. It would be interesting to know how far the builders of these castles were acquainted with that well known rule of fortification, by which the inner gate was so placed that, as the attacking warriors approached, the sides of their column were inevitably exposed to the assault of the defenders. It would also be interesting to understand the reasons for the different modes of defence adopted in various castles—the difference in their internal arrangements—whether any rule guided the mode of placing the apartments of the family of the lord of the castle, his domestic servants, his military retainers, and the stores, commissariat or warlike. It would, moreover, be desirable to know, what was the proper position of the keep; whether it ought to be part of the defence of the enceinte, or in the centre of the court, and whether, at different periods, and in different parts of the country it assumed diverse positions. Again, it would be interesting to know if there was any particular locality for the great hall, or chapel, in the castle; which was generally placed in the inner parts, and which nearer the enceinte; whether the enceinte itself was always a large continuous wall like that of Alnwick; and, what in short, was the purpose of every portion intended to serve in these great military defences. Many of us now present, who have visited Greece, cannot, I think, help drawing a comparison between the castles now exhibited to us and the Acropolis of Athens, and the other ancient cities of that country; and in so doing, we find several points which appear to me to be analogous, as the high walls forming the enceinte, and the central building inclosed within it—in the one instance, the great temple—in the other, the Norman keep. It is interesting to find these features of the ancient Grecian Acropolis repeated in our own mediæval fortresses. It will be observed that many, if not most of the castles here illustrated have an outer and inner ballium or court, here termed baly. It has occurred to me, that possibly the Old Bailey of London may derive its name from having been a ballium or court attached to New Gate, which anciently stood at the end of Newgate-street. I leave it to City antiquaries to enquire into this presumed coincidence. I hope the reverend gentleman, who is deeply versed in this subject, will consent another time to instruct us further by taking a larger sphere, and making us better acquainted with the military spirit of those early times. I should like to have some comparision of the cost of erecting these Edwardian castles and those of modern times, such as Penrhyn castle, or the alterations at Windsor castle. Indeed it might not be uninstructive to compare the outlay on our modern Houses of Parliament with that on the buildings so ably brought before us to night." Mr. Donaldson concluded by moving a vote of thanks to Mr. Hartshorne.

Mr. Tite, in seconding the vote of thanks, said—"I also must express a hope that our reverend friend will hereafter carry his historical inquiry a little further, and explain what has often struck me as very singular—viz., the poverty of the Scottish castles, as compared with the grandeur and magnificence of those of Wales. All the Scottish castles together, could, I believe, be put within the enceinte of Caernarvon Castle; while Bute Castle might be ensconced in the Eagle Tower. I do not know whether the reverend gentleman has confined his researches in the Pipe Rolls exclusively to these castles, or whether, indeed, those ancient records contain any account of the building of the Scottish castles. I would also ask a question with regard to the keeps. There is no keep proper at either Caernarvon or Conway; at least no such keep as the tower at Norwich Castle, and in other Norman castles, to which the defender of the building could retreat as a stronghold when the enceinte was taken. How is that omission to be accounted for? There was, no doubt, a similarity in the character of the erections for defence in Greece, as for instance at Mycenæ and at Athens, and that of the buildings now before us. There was the bold escarpment, or wall built upon the summit of a natural escarpment, as in these Norman castles; and in all, great skill was shown in the way in which the natural irregularity of the ground was turned to advantage. It would be interesting to know the mode of construction employed in the erection of some of these great towers, as well as the thickness of the walls compared with the area they inclose; whether the walls are of solid stone, or merely ashlar filled in with concrete, and bonded; and in short, their general mode of construction, as in all such enormous superstructures great care is requisite to prevent settlements and other evil consequences. I must say, it struck me that 8d. a-day to the clerk of the works was a large amount of pay, as compared with that of the workmen, and particularly, when we consider that 30 or 40 years were expended in the erection of these buildings, instead of 30 or 40 months, as in the present times. I think we are much indebted to our reverend friend for the great industry and talent he has displayed in his able paper."

Mr. FOGGO said that one account stated the master of the works received 13*s.* per week, which at the present value of money would be 10 guineas a week. The whole cost of Caernarvon Castle was stated to have been 250,000*l.*, but that did not include various expenses, such as carrying the stone from the quarry, which were imposed upon the inhabitants of the neighbourhood.

Mr. FOWLER having suggested that the vote of thanks should include the name of Mr. Salvin, to whom they were indebted for the drawings by which the paper was illustrated,

The CHAIRMAN replied that he had a resolution in his hand to that effect, and expressed a hope that Mr. Salvin would give them a few remarks upon his illustrations some other evening.

The vote of thanks was then passed by acclamation.

CEMENTS AND STUCCO.

On the Propriety of the Application of Cements or other Artificially-formed Materials to the Exteriors of Buildings. By JAMES THOMAS KNOWLES.—(Paper read at the Royal Institute of British Architects, May 27, 1850.)

IN submitting the paper which I have now to read, I am influenced by the appeal of the Council to the Members of our Institute for active co-operation; by a desire to assist in removing some of those objections which have been often made to a very valuable class of materials; and by the hope of eliciting a discussion which may be to some who are assembled here to-night both interesting and instructive. But, before I enter upon this difficult and much-vexed question, I wish to state distinctly, that wherever I may express an opinion of my own, unsupported by actual observation, I shall do so with great diffidence, and with the feeling that such opinion may be proved, hereafter, to be erroneous; because I feel that, before the nature of cements or stuccoes can be clearly understood, a larger amount of statistical details, and a much more correct knowledge of the chemical changes which are produced by apparently minute differences in the materials themselves or in the conditions under which they are applied, than is possessed at present, are absolutely necessary.

As my object, on this occasion, is rather to state the result of my own observation and experience, than to repeat what may be gleaned from the works of those who have written upon the subject, I would also ask you to excuse what may appear like egotism in the allusions which I shall have to make to buildings of my own, and to believe that I adopt this course simply because it is impossible for me to speak, with the same degree of certainty, of works with which I am less intimately acquainted.

Although the practice of covering the exteriors of buildings with some description of plastic materials appears to have prevailed from a very early period, it will, I think, be readily admitted, that in our own age and country this practice has been carried beyond all former precedents. It would be quite impossible, on an occasion like the present, to enumerate all the causes which have produced, or have assisted in producing, this result; but, perhaps, as among the most prominent of these, I may mention the cold and humid atmosphere of our northern climate; the impossibility (in many localities) of obtaining, except at a cost too great to be incurred, such materials as will effectually resist the destroying influences of rain and frost; and a growing inclination on the part of our employers to add something of the beautiful in form to that convenience of arrangement and fitness for the intended purpose, without which the most elaborate productions of our art are really failures, or can at best be deemed but splendid errors.

It is true, that, when the practice of employing stuccoes and cements for covering the exteriors of buildings was first adopted, the science of geology had not revealed that valuable page in the great book of nature which has recently attracted so large a measure of study and attention, and that the nature and quality of the materials which compose the crust of our planet are, through the aid of that modern science, better understood by us than they could be by those who were engaged in the art of building before this source of knowledge had been revealed. Yet this additional knowledge upon a subject so deeply interesting to the architect, has tended to confirm the impression which previously existed, by showing him, that in many portions of the united kingdom no building stone can be obtained capable of effectually excluding moisture, or of resisting for any lengthened period the vicissitudes of our climate; and by convincing him, that, in order to secure in such cases, dry, healthful, warm, and comfortable habitations (especially when buildings are rapidly erected, and occupied immediately after their completion), two things are absolutely necessary, and a third is exceedingly desirable:—

1st. That the outer face of all the external walls should have a covering, or skin, of some material impervious to water.—2ndly. That the moisture from the earth should be prevented from rising into the brick, or stonework, by the introduction of some waterproof material into all the external and internal walls and partitions immediately above the ground level.—3rdly. (Where bricks are employed, and a proper amount of careful supervision can be exercised)—that the external walls should be hollow, with an air space of 4, or 4½ inches between the external and internal work, excepting at the jambs of the openings, and the points of junction with the internal walls.

That the necessity for these, or similar precautions, in the erection of dwelling houses in exposed situations, is perfectly well known to the elder members of the profession, and that they adopt them in their practice, I entertain no doubt; but as their advantages may not be equally clear to those who have yet to enter upon the practical department of our art, and lest they should imagine that I am speaking theoretically, and not from actual experience, I will mention—That the house, of which one of the elevations is now exhibited, was erected about six years ago, in an exposed situation, and on a stiff clay soil; that the carcass was carried up in an unusually wet autumn, and the walls exposed to heavy and continuous rains; that no wall battening was used in any portion of the building, which was roofed-in at the end of December, and completed and inhabited by the end of the following October, at which period it was quite fit for occupation; that there has never been since that time the slightest appearance of damp in any portion of it, from the basement to the roof, nor is the smallest settlement perceivable; and this result is, I believe, mainly, if not entirely, attributable to the adoption of those precautions which I have mentioned as being, in my opinion, essential in nearly all cases, and to one other, which is only important on clay soils—that is, the covering of the whole area occupied by the building with a bed of concrete, which should not be less than six, and need not be more than twelve, inches in thickness.

To those who have been accustomed to build only in London, or in other towns and cities, it would, I believe, be quite impossible to convey an adequate idea of the difficulties which must frequently be encountered by those to whom the erection of isolated houses in very exposed situations is intrusted; when (as very frequently happens) no such stone or bricks can be obtained as will effectually resist the rain, and prevent it, when accompanied by heavy gales of wind, from passing through the walls.

I could, if time permitted, mention many remarkable instances of the mechanical force with which the rain is sometimes driven horizontally against the walls of buildings in elevated positions; but I will select one only, which made a great impression on my mind. During a visit to a large building in course of erection on Black Down (the highest ground, I believe, in North Devon), I observed a portion of a nine-inch partition wall saturated with water. As the building had been roofed-in some weeks before, I was a good deal surprised at this appearance; but I had an opportunity a few days afterwards of witnessing what explained to me the cause of it; for, being on the spot during a heavy gale of wind and rain, I stood for some time watching the result, and saw the rain passing through a window opening across eighteen feet of space, and striking with great force against the opposite internal wall, and in the course of about an hour making its appearance on the other side.

Very shortly after witnessing this occurrence, I was called upon to examine a church, which had been erected in a similarly exposed position, through the walls of which (even those of the tower), the rain found admission to the interior in very large quantities. Three or four years having been suffered to elapse, during which this evil was found to be continually increasing, the walls were covered with stucco, of the kind which I shall have hereafter to describe, which proved in that, as it has done in all other cases with which I am acquainted, perfectly effective.

Contenting myself with the remark, that in no single instance have I known the external application of a well-made and carefully-used stucco, to fail in accomplishing the desired object, I will proceed to combat those which appear to me to be the strongest of the objections which are advanced against this mode of protecting and adorning the exteriors of our buildings, viz.—

That cements and stuccoes are not durable, and require frequent and expensive reparations.

That they are very costly; not so much at first, as by reason of the colouring or painting in oil which, it is thought (erroneously I believe), that they afterwards require.

That they are false and deceptive, inasmuch as they, being artificially-formed materials, do, in some measure, assume the appearance of natural productions.

That their introduction has led to all that is false in design, and defective in construction.

And that, when employed in decoration, the enrichments are deficient in that sharpness of outline, and delicacy of finish, by which the productions of the chisel are distinguished.

Now, I must readily admit, that a very large proportion of the cement and stucco work, which we see in London and its neighbourhood, is so faulty in design and defective in execution that it is difficult to find language strong enough for its condemnation. I know that many of the structures which we see bedizened with what are intended for, and by some, perhaps, are dignified with the name of, decorations, are indeed but whited sepulchres. That many of the bricks used in them might, by a strong man's hand, be crushed to powder. That the mortar is composed of earth, dug from the foundations, mixed with a very small quantity of white chalk lime. That the timbers are defective, both in quality and scantling; and that, in short, the whole affair, from the foundation to the roof, comprises all that is miserable in construction and false in taste.

But I cannot think that these defects are referable to the use of stuccoes and cements, or that by the external application of these materials, structural defects can be successfully concealed. On the contrary, I believe that the cracks and openings produced by the settlement of piers or arches; by the shrinkage of timber, improperly introduced; by the fracture of stone lintels, or other such like causes, are to the full as conspicuous in a stuccoed building as in one which is faced with brick or stone, and quite as difficult to repair effectively. Indeed, I feel so strongly the necessity of extreme care being taken in the construction of buildings which are intended to be covered with cement, that I not only turn inverts under all the openings, but frequently omit also the reveal arches and the timber lintels; carrying, instead of them, relieving arches through the whole thickness of the wall. I have never yet seen any cracks or settlements in the walls of buildings thus constructed, when carefully stuccoed; and I see no reason why this mode of building should not be almost universally adopted, when cement or stucco are intended to be used, as it is more effective and durable, and is not at all more costly.

It has been frequently asserted that no chemical or mechanical combinations of matter will result in a successful imitation of what has been effected in Nature's laboratory; and that no artificial materials can be made equal in durability to natural productions. Yet it would, I think, be difficult to find in England, any description of building stone more capable of withstanding for a lengthened period the vicissitudes of our climate, than thoroughly well made, and well burnt bricks, and *terracotta*.

It is true, that the firing to which bricks and *terracotta* are subjected may be fairly considered as constituting a great difference in their power of resisting atmospheric influence, as compared with any of the cements which are now usually employed; but it is quite certain that cements and mortars have been made, which, for hardness and durability, were almost, if not quite, equal to the hardest bricks. And I cannot doubt the possibility of again doing in our own time what was certainly accomplished at a period when, however much grandeur of conception and just appreciation of beautiful forms might have exceeded those with which mens' minds appear to be endowed at present, the physical sciences were but little known, and contributed only in a very slight degree to the comforts and the social enjoyments of the human race. A proof that I am not overstating the power of resistance to atmospheric influences which mortars and cements, when properly prepared, do undoubtedly possess, is afforded by a piece of Roman mortar from Wroxeter now exhibited, which has evidently been used as an external cement or stucco, and which must have been exposed to the action of rain and frost for fourteen or fifteen hundred years.

It is said that failures frequently occur in works which have been executed in cement, and that the decorations produced in artificial materials are always deficient in that sharpness of outline and delicacy of feeling which constitute the great charm of architectural enrichments. But I would ask, whether it is not possible to lessen, if not wholly to remove, these very grave objections, by great attention on the part of the architect in designing, and especially in inspecting the modelling of his enrichments whilst in the clay? By a determination, on his part, to become thoroughly acquainted with the nature and properties of all such cements as he intends to employ for the covering or decoration of his buildings, whether internally or externally; so that he may be enabled to form a correct opinion when he sees the work in progress, whether the materials have been properly prepared by the manufacturer, and then sent to the building in a state fit for use by the contractor, and are being judiciously mixed and applied by the workmen and labourers. By employing in the execution of his works such men only as are thoroughly masters of their business, making them responsible for the reparations and reinstatements of any portions of the works which may fail within five or seven years after their completion; and by securing the services of clerks of the works, or foremen, who are well acquainted with the nature of the cement to be employed, and who will keep a vigilant eye over the proceedings of the workmen.

But some of my friends will, doubtless, tell me, that if, in order to prevent failures in the effect or in the durability of cement work, all this care and circumspection are required, failures and imperfections are quite certain to occur. This may be true; but if true as regards cement, it is also true of other works required in the erection and completion of a building. And how, let me ask, can the imperfections so often found to exist in the plumber's work, and in the drainage of our buildings; in the carpentry of the roofs, floors, and partitions; in the foundations, and the brickwork, be prevented? How can the disintegration and crumbling away of the most prominent members of stone cornices, strings, balconies, and chimney tops, within a few years after their completion, be avoided, excepting by the same degree of knowledge, care, and skill on the part of the architect, the contractor, the clerk of the works, the foreman, and the workmen, which I have insisted on as essential to the successful employment of cements?

There are, however, among those who have most strenuously opposed the use of these materials, a considerable number who ground their objections not on the want of durability, the chances of failure, or the extra cost; but on their want of reality, their resemblance to some natural productions, and the smallness of their cost, as compared with the stone casings which they sometimes resemble. Now, however desirable and proper, and commendable it may be, and doubtless is, to introduce into the structures which are reared in honour and for the worship of the Great Creator, the most valuable and the choicest of earth's productions; yet it must, I think, be admitted, that the qualities of the material in which the thought of a great artist is embodied (so that it possess but durability and beauty), are in all other cases of very secondary importance. I fear, however, that the disposition to place so high a value on costly stones, and woods, and metals, which appears lately to have prevailed amongst those who profess to be the patrons of the arts, is calculated to produce on the minds of the people generally, false impressions; because it leads them to admire that which is difficult of attainment except to the possessors of great wealth, instead of that which is truly grand and beautiful, and original in design.

That species of admiration which is excited by the costliness of the materials employed in works of art, has always appeared to me to partake considerably of the vulgar and the barbarous. For, as much as the heavens are higher than the earth, so much, do I believe, the emanations of the mind to be above and beyond the mere vehicle in which they are embodied. Whatever is really beautiful in form, or truly harmonious in colour, should be enshrined, as amongst the most precious of man's productions; and I cannot doubt that the time will come (although, perhaps, not in our day), when the immaterial thought of the artist shall be more highly valued than any stones or woods, or metals, however rare or costly, in which it may be clothed. Much better is it, in my opinion, to have the emanations of deep thought, the creations of those minds which have been embued with a due appreciation of the beautiful in form, embodied in materials which might endure for only half-a-century, than the eternal stereotypes we now see rising throughout this great and wealthy country, perpetuated in stone which would endure for countless ages.

It is not, I believe, because there exists among our countrymen any lack of mind to conceive, or of constructive skill to carry out the most gigantic undertakings, that so comparatively small a number of buildings remarkable for beauty, for originality, or for grandeur of design, have lately been produced. But, partly, because mens' minds have been directed more towards other objects than the arts; partly, because the carelessness of the public, and the unaccountable apathy of the profession, have allowed a small and non-professional party to assume the direction of our art, and to introduce a movement of retrogression to the styles and fashions of a former age; which must, I fear, if not soon checked, prevent for some long period all progress and improvement. And is it strange and unaccountable, that architects and architecture are favoured with so small a share of public consideration in the present day, when it is remembered that, whilst in almost everything connected with our social condition there has been manifested the strongest determination to encourage progress and improvement—those who profess to be the patrons and supporters of this really great and noble art, have exhibited an equally strong determination to go backwards; to prevent, so far as in them lies, the introduction into the ecclesiastical edifices of the nineteenth century, a single form or feature which has not been copied from some mediæval building; and even to disfigure the windows of our churches with such representations of the human form as were produced by the old glass painters, because they were unable to give more correct delineations?

Professor Cockerell, in (I believe) his fifth Lecture of last Session, at the Royal Academy, speaking of the fashions which have prevailed in architecture, is reported to have said:—"The proofs of this fact (fashion in architecture) abound. Churches were Grecian, and for the last twenty years have been Gothic; intensely Roman Catholic. The sense has been wanting to understand that we do not want a Greek temple for the reception of a chryselephantine statue, nor a Roman church for processions, and a sight only of the Eucharist; but a Protestant auditorium, suited to the Anglican ritual, to which great purpose, all form of dress, of whatever order and fashion, must bend and adapt itself." In the opinions thus expressed by the learned professor, I believe that many thousands of his countrymen do most cordially agree.

Without the slightest intention of making any disparaging remarks on the labours of those architects who have, with so much care and skill, sought out and given correct and beautiful illustrations of the structures and architectural details of the middle ages, I would respectfully suggest that the time has now arrived, when the efforts so strenuously made in obtaining intelligence on these subjects may well be slackened, and the talents of those gifted individuals be directed to investigations which may result in the production of novelty, beauty, fitness in design, and of greater economy, combined with durability and beauty in the construction of our buildings; in adapting to the wants of the existing generation those great discoveries in physical science which may, and ought to increase so largely the diffusion of comfort and rational enjoyment amongst all classes of the community; and in making our age and country as remarkable for the dissemination of a love of true art amongst the masses of the people, as it is for an amount of commercial energy and enterprise which stand unrivalled in the annals of the world.

The homes of England have now, for many years, been considered as worthy of our best attention, and no small portion of that industrious perseverance for which our countrymen are justly celebrated may be attributed to the desire of possessing a commodious and healthful dwelling which so extensively prevails amongst them. There was a time when men cared little whether or not these homes were situated in the country, so that they contained the requisite accommodation for their families. But this indifference to position, which some time before the introduction of railway travelling had been gradually lessening, has, since the development of that wondrous system, almost wholly disappeared; and men of all classes and conditions, influenced mainly by the facilities for travelling which are now placed within their reach, appear determined to find, or to build, in some rural district, such habitations for themselves and their families as shall combine, with every provision for comfort and convenience, as much of symmetry and beauty as the talent of their architect and the means at their disposal will allow. Whilst, however, men of various ranks and stations are eagerly bent upon obtaining the unquestionable advantages of a country residence, and are disposed, in many cases, to incur for the attainment of this object, such an expenditure (however large) as may be really necessary, they are almost invariably unwilling to make any considerable addition to their outlay, either for the purpose of building or casing their houses with stone, instead of artificially formed materials, or for the introduction of features which, although generally found in ancient buildings, are now, from changes of habits and modes of living, no longer useful. That this feeling, whether wright or wrong, does very extensively prevail, not only among the professional and trading portions of the community, but that it is also found in many cases to exist among those who are possessed of high rank and station, must be well known to many members of this Institute.

Now, if we admit that a dry, commodious, and well-arranged house does very materially assist in promoting the health and happiness of those who occupy it; that the present cheap and easy mode of travelling is leading to a very large increase of private dwellings in the country; that those by whom these dwellings are erected, although for the most part anxious to combine convenience with beauty, will not consent to any considerable increase of expenditure in the employment of natural instead of artificial materials, when the latter are well adapted for the required purpose, and possess both durability and beauty; and that in many localities no stone or bricks can be obtained, which of themselves are capable of excluding rain, or of resisting the destroying influences of frost; it must, I think, be also granted, that few subjects can be more deserving of our best attention, than those artificial coverings or skins which are, in many cases, really indispensable, and might in many others be most advantageously employed.

To those objections which are made against these artificial coverings on account of the expenses said to be incurred in reparations, and in frequent repetitions of colouring or painting, I attach but very little weight, because my own experience has convinced me, that if the right materials are employed, no painting or colouring will be required, and that the total cost of reparation (when the materials are of good quality and the work well executed) does not amount to any thing like one per cent. on the original cost, within five years from its first completion; and after that period has elapsed, I believe that its durability for fifty, seventy, or even a hundred years, may very safely be predicted. That the extent of durability and adaptability which artificially formed materials possess, or which by further improvements and discoveries may hereafter be obtained, is the really important question, it seems to me impossible to doubt; for it surely never can be seriously asserted, that if by an expenditure of one thousand pounds, or the amount of labour which that sum represents, we can obtain in an artificial material more warmth and greater freedom from damp internally, with as much beauty and durability externally, as can be produced for four thousand pounds in stone, we are to adopt the latter, and reject the former? Shall we not then act like faithful stewards if, in many cases, when called upon to prepare designs for the dwellings of our countrymen—buildings which are to be numbered among the homes of England—we devote the money which might be expended in an external case of stone, to the increase of internal accommodation; to the enlargement and proper decoration of the apartments in which our clients and their families are to spend by far the larger portion of their time; to rendering the building proof against the ravages of fire; to providing copious supplies of water, and numerous accommodations and conveniences, which although required by the habits of the age, and essential to the comfort and well-being of the tenants, are yet not always found even in the most costly of our houses?

As to the peculiar properties, the excellencies, or the defects of the various cements and artificially formed materials, to which the attention of the profession is so frequently solicited, it is not my intention, on this occasion, to say much. There is, however, one material which can perhaps scarcely be called a cement, according to the general acceptation of the term, to which my attention has been a good deal directed, and which has been very extensively used under my directions. It is one with which most of you are familiar, and I should not venture to offer the few remarks upon it with which I am about to trouble you, if I did not believe that I have had more than ordinary opportunities of testing its capabilities in various ways, and in remarkably exposed situations. As it is one, moreover, with which manufacturers of cements have little or nothing to do (the process required in its preparation being extremely simple and inexpensive), whatever I may say in favour of its durability and beauty will not tend much to the advancement of any particular interest.

This material, usually known as stucco, is in reality nothing more than mortar, formed either of blue lias lime, ground or slaked, and mixed with pounded slag from the smelting furnaces; or of the grey stone lime so extensively used in London, ground and mixed with clean, sharp, carefully-washed, silicious sand, in the proportion of one part of lime to three parts of sand, excepting for the outer surface or facing, where nearly equal parts of lime and sand are generally used. The lime and sand (whether silicious or metallic) should be mixed well together (or gauged, as the workmen call it) in small quantities, and applied immediately to the work, which, in order to ensure success, should, in all cases, be first well saturated with water. With this mortar, formed in either of the two ways which I have mentioned, and used by experienced and skilful workmen, not only may a durable casing impervious to water be obtained, but mouldings and enrichments of all kinds can be also executed, with a sharpness and delicacy of finish which it is impossible to surpass.

In the building here represented, which was erected about seventeen years ago, and which occupies a very elevated and exposed site on the borders of Hampshire, not far distant from the sea—the capitals and bases, and the flutings of the shafts of the columns (which were executed in a most masterly manner, and with a degree of accuracy and truth, as to entasis and details, which left nothing to be desired) remain as yet uninjured. And the arrises of the fillets between the flutes, even of those columns which are exposed to the south-west, without protection of any kind from the violence of the winds and rain (with which, from that quarter, we are so often visited) were, when I saw them about ten months since, as sharp and perfect as any which can be formed by the chisel of the mason.

I could mention a great number of buildings, some of them much larger and more highly decorated, on which the same material has been successfully used. But I have selected this, because it was the first of any magnitude on which I ventured to employ it; and it is the oldest work of my own to which I can refer. It is true, that a period of seventeen years (although much longer than some of the building stones which have been used in this country would endure under the same influences) offers but a narrow foundation whereon to build an hypothesis as to the permanent durability of any kind of material. But we all know that mortar, such as that which I have mentioned, will (if it escapes the trials to which it is subjected for the first few years, before the induration produced by the absorption of carbonic acid has made much progress) continue to increase in hardness, for a period of which the limits have never yet been ascertained. I know of one case, where it was used as an external casing about seventy years ago, and it has now become so hard and compact as to render it almost impossible to doubt its continued durability. I remember, too, that about a year-and-a-half ago, in clearing a site for some new buildings, I had to remove a balustrade which had been put up about fifty years before. The capping of this balustrade, which had been executed in Bath stone, was in a most deplorable and dilapidated condition, but the ballusters (formed of grey stone lime, and rather fine, but very sharp silicious sand) were, in all respects, quite sound and perfect, exhibiting not the smallest approach to decay or disintegration; indeed, nothing but the fact of their being hollow, which was disclosed on their removal, would have convinced the workmen that they had not been carved out of some hard and compact stone.

In the very interesting paper on the Brick Churches of Germany, which was read here some time since, it was stated, that the mortar used in their construction, after the lapse of more than 500 years was so hard as to be capable of receiving a polish like marble. This, although a remarkable, is by no means a singular instance of that durability which judiciously formed compounds of lime and sand do undoubtedly possess; and it is on account of the abundant evidence which exists of their power of resisting atmospheric influences, that I have hitherto given them the preference over all other kinds of artificially-formed materials which have been used for covering the exteriors of buildings.

It was my intention to enter, at some length, into the respective merits of the blue lias and the grey stone limes; but finding it impossible to introduce this and other subjects connected with them in the compass of a single paper, I have been obliged to reserve the consideration of them for some future opportunity, when I may, perhaps, trespass again upon your attention.

Remarks.—In the discussion which followed, Mr. Francis expressed his regret that the paper just read contained matter not quite germane to its subject, which he considered to be one of great practical importance, as the employment of stucco must occasionally very properly take place. He then proceeded, at some length, to vindicate architects of the present day from the charge of servilely copying the buildings of the middle ages, which had been advanced by Mr. Knowles, and observed that the charge of want of novelty and of copyism applies to those who affect the classic styles, rather than to those who try to follow the spirit of mediæval architecture. Recurring to the subject of cement—he held it to be perfectly legitimate to apply it to cover a plain surface; but he considered it a material quite inadequate for the purpose of minute and elaborate design in ornamental work, which, when executed in it, must want the freedom of touch and the artistic feeling belonging to the chisel. Increased knowledge of the subject of building stones may enable us, eventually, to render the least enduring of them impervious to water, by injection of a fluid, or other means by which their natural defects may be overcome; but he felt assured, that we shall never emulate the buildings of the middle ages, nor discover a new style, by introducing in minute decoration the material so highly approved of in the paper.

Mr. Knowles explained that reference had been made to designs on the walls, solely for the purpose of illustrating the enduring quality of stucco in an unusually exposed situation—that he himself felt the evils of which he had complained, and did not profess to be free of them—but he thought, that if the talent which had been recently brought to bear upon mediæval architecture, had been directed into a more useful channel, greater progress might by this time have been made towards a style creditable to the age in which it was introduced.

Mr. G. G. Scott thought the evils complained of arose, not from a *want* of knowledge, but from its too extensive character; and and that we are acquainted with so many styles, that we do not know which to select. Classic architecture, after having had some three hundred years to develope itself, had, in many instances, degenerated into the state complained of. Without, in any way, retrograding to the manners and customs of five centuries ago, the remedy would be the introduction of a style capable of great development, which, if properly carried out, would, he believed, be found more adapted to the wants of the present day than any modification of the classical style. Without objecting to the use of plaster in proper situations, he certainly held the use of Roman cement to be destructive of the true character of art, by assisting in the imitation of other materials, and thus producing false appearances. The charge of copyism he repudiated altogether: what they did attempt by the study of ancient examples was to catch their spirit, and they were encouraged to proceed, by observing the progress made year by year, which showed that the revival had given greater proofs of vitality than architecture of an exclusively classical character had given during three centuries.

Mr. Knowles considered that a building cased with stone presented an appearance equally false as one covered with cement. No mediæval erections were, in his opinion, superior to the upper portion of the steeple of Bow Church, nor is there a structure in the world so exquisite as the outline of St. Paul's.

Mr. Donaldson, Hon. Sec. F.C., said, that, æsthetically speaking, stone must be considered preferable to stucco, on account of its greater beauty and variety of tint, while the jointing given to cement, in order to make it imitate stone, produces evidently a false appearance. He then pointed out the superiority in effect and appearance, which a figure executed in marble possesses over a cast in plaster, and demonstrated that this superiority is due to the inherent beauty of the material, and not to the mere circumstance of the marble being the more costly in point of expense.

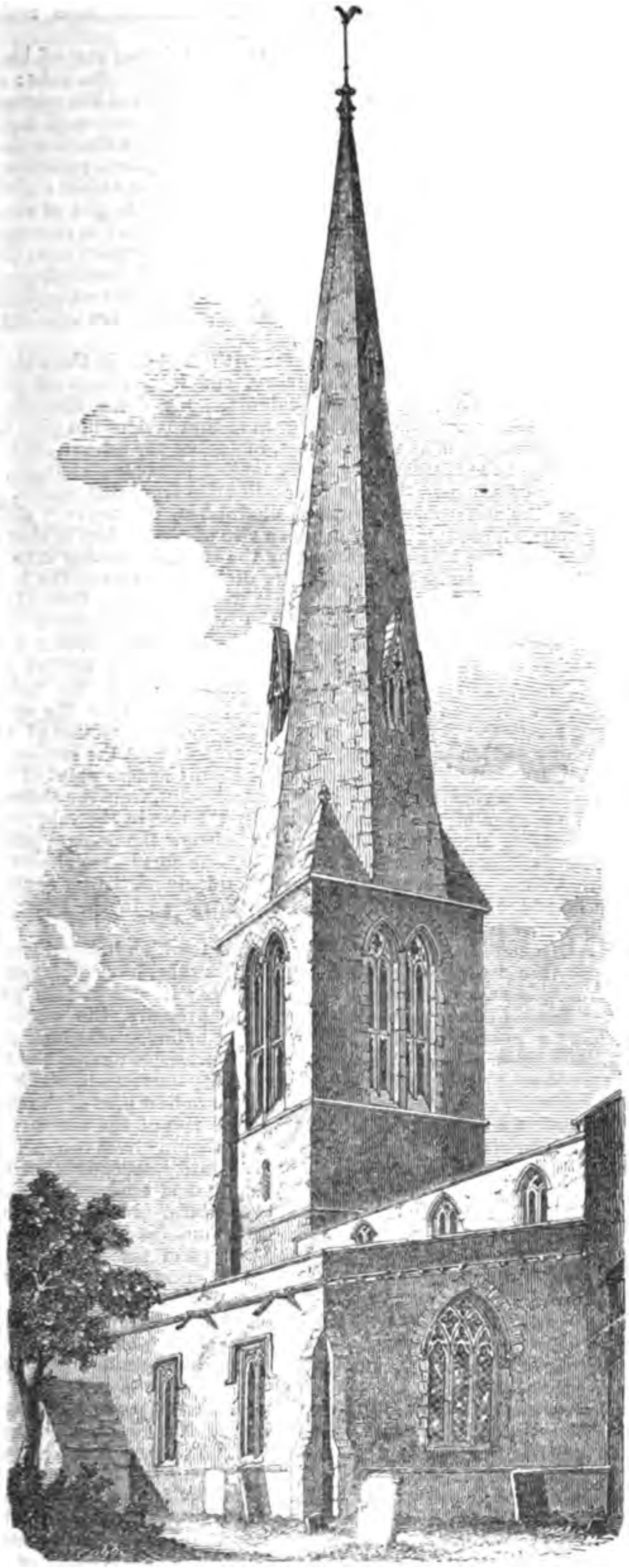
An observation by Mr. Scott, that there is more copyism in the details of Sir Christopher Wren's works than in most Gothic buildings he was acquainted with, called forth the expression of a directly contrary opinion from Mr. Billings, who also took the opportunity to dissent from a statement made at the last meeting, that all the Scotch castles might be placed within the walls of one Welsh castle. In support of his counter-statement, Mr. Billings gave instances of the extent of ground occupied by the castles of Edinburgh and Stirling.

The President having pointed out the advantages arising from meetings such as the present, in eliciting discussion on useful topics, a vote of thanks was then passed to Mr. Knowles, and the meeting adjourned.

STANION CHURCH, NORTHAMPTONSHIRE.

There is a range of churches along the northern border of Northamptonshire, whose detached position renders them less known than their merits deserve. Though somewhat plain in their general aspect, there is a dignity of proportion, and stateliness of outline very satisfactory. Of these may be enumerated Cottingham, Brampton, Desborough, Loddington, Corby, and Stanion. The latter, which may be taken as a sample, is remarkable for its slender and unusually lofty spire. Many portions of the church exhibit portions of early work, and others which, upon examination, prove to be of much later date, are nevertheless *in character* correspondent with these.

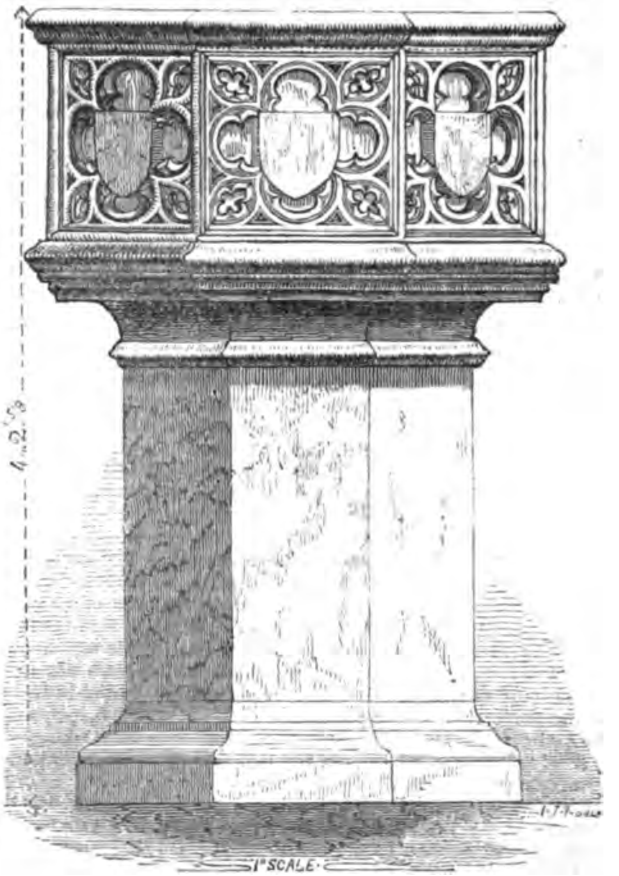
The chancel has some very good windows, with incipient tracery in the heads. The aisles and clerestory are mostly Perpendicular, and do not call for particular notice. The long double belfry lights in the tower, with their transoms, and the small buttresses (attached only to the western corners), will be observed as peculiar.



STANION CHURCH, NORTHAMPTONSHIRE.

FONT, WESTMINSTER ABBEY.

Among the various improvements made in the Abbey by the Dean and the architect, Mr. G. G. Scott, that of opening up a view of the west window of the south aisle and the font by the removal of the modern monument standing under the side arch of the south-west tower, although not the greatest, is by no means the least effective,—the long perspective view down this most exposed aisle being now seen in its full extent. A fine screen, of Perpendicular date, was found behind, and totally obscured by the monument now removed. In the space under this tower the font was placed, and seems to have been, from its out-of-the-way position, quite overlooked,—this being, as far as we are aware, the only representation of it ever published. The base to the neck mould is modern, and may have been a poor copy of what the original was. The shields have been painted, small particles of which yet remain; and the quatrefoils probably also. In the same place is a seat, of about the date of 1640, bearing a remarkable resemblance in the ornaments of the panelling on the back of the pulpits to be seen at Wensington and Aveley, Essex. On the bottom of the plinth stones to screen remains the working drawing of the section of the mullions above it: how they managed to work from it is rather difficult to say. If those men who think that Gothic architects only copied each other in any one style, were to compare this screen with those of Abbot Islyp's Chapel, that behind the altar, Henry V. Chantry, and Henry VII. Chapel together, and see the spirit of each designer self-evident in his own work, they would learn a lesson which might do a little towards preventing their setting themselves up as critics on things which they are supremely ignorant of: rendered so from the want of energy enough to make themselves acquainted with the subject on which they would treat; and so, like tall chimneys, can do nothing more than make a great smoke.



FONT, WESTMINSTER ABBEY.

METEOROLOGY.

On the Instruments employed in Meteorological Observations.

By John Drew, Esq., F.R.A.S.

The noble mansion of Hartwell, situated in the fertile vale of Aylesbury, and at the foot of the Chiltern Hills—the stewardship of which is accepted by those who are anxious to resign one of greater responsibility—is not devoid of interest from its historical associations. Here in seclusion resided the last of the Bourbons who bore the title of "King of France." The visitor to Versailles will call to mind the "Jardin à la Hartwell," which bears testimony to the agreeable recollections of this temporary retreat that followed the recluse when the sequence of events had placed a crown on his head. In the spacious and elegant library, Louis XVIII. attached his signature to the document which restored him to the throne of his ancestors. With objects far other than political, a few lovers of science had assembled in this room, at the invitation of the present proprietor, Dr. Lee, on the 4th of April, 1850, for the purpose of taking into consideration the present state of meteorology, and of adopting such measures as might conduce to its advancement. The result of their deliberations was the formation of a society, to be called the "British Meteorological Society," of which Dr. Lee was appointed Treasurer, and James Glaisher, Esq., F.R.S., F.R.A.S. (of the Royal Observatory, Greenwich), Secretary. The second meeting of the Council was held on the 7th of May. Within a month the Society has numbered ninety-five members, has elected as President, S. C. Whitbread, Esq., F.R.A.S., as Vice-Presidents Lord Robert Grosvenor, M.P., Hastings Russell, Esq., M.P., General Sir Thomas Brisbane, K.C.B., F.R.S., and Luke Howard, Esq., F.R.S.

Trusting that this movement will give an impulse to the study of atmospheric phenomena, and anxious, as one of the original members of the Council, to promote its objects, I avail myself of your offer to discuss in a popular manner the construction of those instruments employed in meteorological observations, the value of the observations themselves, and other points which may be likely to interest and draw attention to a science which is yet in its infancy—a science which calls upon all who imbibe the vital air, the *lumen spirabile cœli*, to co-operate in ascertaining the effects it produces on our sanitary condition: its powers as the medium of conveying the deadly pestilence or the health-inspiring antidote.

To promote this desirable object, it is my intention to describe the principles of construction of such instruments, and those only, as may assist a labourer in this ample field in contributing his share to the accumulation of phenomena from which we may fairly hope will be eventually deduced the laws regulating the atmosphere—the source of life and support to every member of the human family.

I.—*The Barometer.*

Fill a glass tube 32 inches in length with mercury, invert it in a vessel of the same liquid, and you have a barometer: the column of mercury in the tube will descend until its weight exactly balances the pressure of the atmosphere on the surface which is open to its influence. A scale, measuring the height of the top of the column above the surface of the liquid in the vessel, will show from time to time the variations in the pressure of the air vertical to the place of observation.

Simple as this may appear, we find, when we wish to arrive at results sufficiently accurate to be of any value for scientific purposes, various sources of error, which must be detected and their value ascertained. The vacuum at the upper part of the tube, if the instrument is well constructed, is the most perfect that can be produced; to prevent the rise of particles of air which may be diffused throughout the mercury, or may have been attached to the sides of the tube, the mercury should be boiled in the tube, and the perfection of the vacuum may be tested by inclining the tube and driving the mercury to the closed end, on striking which it will give a sharp and sudden tap if no air or moisture exist above the mercurial column.

If a piece of glass tube, not more, we will suppose, than ·4-inch in diameter, be inserted in water, the water will rise within it by capillary attraction to a height greater or less according to the size of the tube—the surface of the water within being concave: on the contrary, if the same tube be plunged into mercury, it will repel the metal all around, and the surface of the mercury within the tube will be convex, the top of the curve being depressed below the level of the liquid in the vessel. Now, unless the tube of the barometer is so large* that the the capillary attraction may be disregarded, it is evident that a correction must be applied to the observed height of the mercury in the barometer to reduce it to the true. This correction is always +, and is usually determined by the maker: if it be not, it may readily be obtained from tables when the diameter of the tube is known.

The scales of barometers adapted to scientific use are of brass throughout, extending from the cistern to the top of the tube: an increase of heat will be followed by an expansion both of the mercury and the scale. If the two metals expanded equally for equal increments of heat, no error would arise; but mercury expands more than any other metal known. Now supposing the atmospheric pressure to remain the same, but that the temperature has risen within a given period from 40° to 60°, the index would show (at a height of about 30 inches) a rise of 0·054 inch, which would be due not to increased pressure, but to the excess of the expansion of the mercury over that of the brass scale. It has been agreed to reduce all observations to a standard temperature, viz., 32 degrees of Fahrenheit—the freezing point of water—and for this purpose corrections are tabulated, and may be obtained by inspection.

In most barometers a thermometer with its bulb in the cistern shows the temperature of the mercury, and it is presumed that this is the same throughout the column. Sir John Herschel† objects to this arrangement on the ground that it does not give the mean temperature of the whole mass, including the column; but in a room where the temperature is not subject to sudden changes, it may fairly be assumed that no error will arise from this source.

When the atmospheric pressure diminishes, the mercury sinks in the tube, and consequently causes a rise of the surface of that in the cistern. The height measured by the scale, supposing it to be fixed, will not then be the true, as its divisions presume the level of the surface to be constant and not fluctuating—in fact, there will only be one point at which the measured distance will exactly agree with the real distance of the top of the column from the surface of the mercury in the cistern. This is termed the *neutral point*, and is ascertained experimentally by the maker during the progress of construction, and engraved on the scale, together with the proportion between the area of a section of the tube and a section of the cistern. It is evident that the surface of the mercury in the cistern will be lower than the zero point of the scale when the reading is above the neutral point, from the abstraction of a portion of its contents to supply the rise in the tube; and that it will be higher when the reading is below the neutral point. If the capacities be as one to forty-two, one forty-second part of the difference between the neutral point and any particular reading must be added in the former case, and subtracted in the latter, to obtain a corrected height.

Mr. Glaisher is not friendly to barometers to which it is necessary to apply the capacity correction. The glass tube, having a certain thickness, dips, of course, into the cistern: as the cistern gets fuller from a decrease in the atmospheric pressure, the mercury encloses a greater portion of this hollow cylinder of glass, and therefore rises higher (*i. e.* the surface approaches nearer the top of that in tube) than is shown by the capacity correction, which, as we have seen, only compares the area of the hollow part of the tube with that of the cistern. Again, when the rise of the mercury in the tube from increased pressure, draws the supply from the cistern, the surface is reduced in height by a quantity dependent on the volume of the section of the tube which it had enclosed, beyond what the correction for capacity would indicate. Nor is it an easy matter to calculate the effect which these annulus-like sections of the glass tube would produce on the readings of the barometer at different heights. He has, in consequence, superintended the construction of barometers in which the capacity correction should be superseded, at a very reduced price; and, as it is of importance that all observers who communicate with him should be possessed of instruments which should give uniform results, I shall describe the construction more at length. They are made by Barrow, of Oxenden-street, of whom they may be procured, price *7l. 7s.*, and are all compared with the same standard by Mr. Glaisher himself, who supplies the results with the instrument when it is sent out into the world.

The cistern consists of a hollow cylinder of glass closed by a leathern bottom. A small index points downward towards the surface of the mercury, and the first step in taking an observation is by means of a screw which acts on the leathern extremity of the cistern, to adjust the level of the mercury until it exactly touches

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* The diameter of the tube of the Greenwich standard is 0·565 inch; the correction for capacity is 0·202 inch.

† 'Admiralty Manual of Scientific Enquiry.'

the ivory point; the same action either raises or depresses the column of mercury, and, as the extremity of the ivory point is the zero of the scale, the reading will show the real height of the mercurial column above the surface of the liquid metal in the cistern, subject to only two corrections—viz., that of temperature and capillary action. The barometer is attached to a mahogany slab, projecting forward about two inches, and is free to turn on its axis in any direction. In reading off the scale a moveable ring is made to form a tangent to the curved surface of the mercury in the tube, a piece of white paper to reflect the light being placed behind it; with very little trouble the temperature and capacity correction may be combined in one, together with a small zero correction to reduce it to the Greenwich standard. When a table is thus formed, the absolute height of the barometric column may be ascertained from the reading by the application of one correction only, and that with the accuracy which has hitherto been attained by standard barometers at three times the price. As Mr. Barrow makes twelve of these at the same time, there is a fair chance of their readings being identical; and this is reduced almost to a certainty by the pains which Mr. Glaisher takes in comparing them with the same standard, and supplying the zero correction, which is never more than a few thousandths of an inch.

An example from a series of comparisons, lately taken with a barometer by Newman (very excellent of its kind), to determine its zero correction, and one of this construction, will show how much labour is saved in the reduction of observations taken by this improved instrument.

Newman's.		*Barrow's.*	
29·375	reading of the scale	29·376	
−·018	capacity	−·051	temperature + capillarity
29·357		29·325	corrected height
+·032	capillarity		
29·389			
−·064	temperature		
29·325	corrected height		

With some labour it would be possible to combine all the corrections for Newman's barometer in one—a plan I am about to adopt for the reduction of three years' observations with the instrument which was made purposely for me. In lieu of the glass cistern and leather bag, a double iron cistern, with a solid bottom, is introduced; and, with great simplicity, the mercury is secured for travelling by stopping off the greater portion after the instrument is inverted. It has accompanied me several hundred miles, and, without requiring special care, has returned uninjured. I have applied it to the purpose of measuring heights with great success, and have the utmost confidence in its indications.

II.—*Dry and Wet Bulb Thermometers.*

To render observations of the temperature of different places of any value to science, the instruments employed should be of the most accurate construction—the indications of the thermometers, for example, should be worthy of reliance to the tenth part of a degree: it is difficult, but not impossible, to attain to such accuracy. Out of twenty-five thermometers made for Mr. Glaisher, in 1843, by Watkins and Hill, twenty of them agreed within one-tenth of a degree at every part of the scale—the extreme difference between the readings of the remainder was half-a-degree. In his experiments on the radiation of heat from the earth at night (Phil. Trans., Part II., 1847) he mentions his possessing at one time upward of fifty instruments, whose extreme difference of reading from the standard was a constant quantity of half-a-degree in one thermometer, and of 0·2° in three others, the remainder being absolutely free from error.

These facts are mentioned to show the possibility of obtaining perfect instruments, but especially as a caution against the purchase of thermometers which have not been tested, or whose performance has not been guaranteed by a maker of high character: it is evident that no comparison of the mean temperature of different places can be made with instruments whose errors are not reduced within very narrow limits. Consideration of certain sources of error in constructing thermometers will at once show that those exhibited in shops, and sold for a trifling sum, have the name by courtesy and not by desert. To ensure delicacy in the construction of a thermometer, many niceties demand attention—two especially may be worth mentioning.

1. The bore of the tube should be uniform throughout: if it be not, the length of the degrees will not be the same at every part of the stem.

2. The observer should be fully persuaded of the accuracy of the scale which is adapted to the instrument, both as regards the zero point and the uniformity of the divisions. The zero point is ascertained by plunging the thermometer into melting ice, when its reading ought to be 32°. But it is a singular fact, that this zero point may be found to change, and hence it should be tested from time to time, and an index error allowed should any alteration have taken place. The thermometers used by the observers whose returns are published quarterly by the Registrar-General, have, for the most part, been examined by Mr. Glashier, and compared with a standard; and thus, as far as possible, uniformity of result is provided for: a character is given with the instrument, consisting of a series of comparisons with the standard, which is thus accomplished. The two thermometers are plunged into water of the temperature of the highest reading of the one whose character is the desideratum, and a series of comparative readings is taken as the temperature lowers. The differences will supply corrections to be applied at the various temperatures to reduce the readings to the standard; but in those supplied by Barrow, after Mr. Glashier's comparison, the differences are so minute that they may be safely disregarded in practice.

The wet and dry bulb thermometers are simply two thermometers side by side, which are presumed under the same circumstances to give similar indications. The dry thermometer, of course, shows the temperature of the air; the wet thermometer has its bulb surrounded with muslin, and from it lead a few inches of lamp-wick into a small vessel of water: the reading of this latter will in general be below the dry, and a comparison of the two will supply data for ascertaining the hygrometric state of the atmosphere. Without entering too far into the subject, a few words of explanation may be desirable.

Under general circumstances the atmosphere will take up the vapour of water: the drier it is the more rapidly will evaporation proceed, and the more slowly as its condition approaches that of complete saturation. When in that state no more moisture is capable of being held in suspension. Now, as evaporation proceeds, heat is absorbed by the conversion of the water around the bulb of the thermometer into vapour, and the mercury in the wet bulb will fall a greater or less number of degrees according to the dryness of the atmosphere. When the air is saturated, the readings will be the same. In Mr. Glaisher's 'Hygrometrical Tables' the subject of the wet and dry bulb thermometers is fully discussed, and, by their assistance, various interesting particulars may be deduced from the simple record of the different readings of the two. The most important of these deductions is the temperature of the dew-point, or that degree at which the atmosphere will part with its moisture, or will be cooled down to the point of saturation. The capacity of air for holding aqueous vapour in suspension diminishes with the abstraction of heat. The dew-point is that degree of temperature at which saturation is attained and moisture deposited. The difference between this and the temperature of the air has been investigated, and formulæ have been given by it which may be deduced from observations with the wet and dry bulb thermometers; but in Glaisher's 'Hygrometrical Tables' the dew-point may be found at sight from the readings of the wet and dry bulb; and I believe I am correct in stating that these results have been obtained from observation and not from theory.

The elegant hygrometer of the late Professor Daniel gives the dew-point by inspection; but, as it is attended with some inconvenience and expenditure of time, it has not come into general use. Many observers, like myself, occasionally verify, by means of simultaneous observations with it, the deductions from the dry and wet bulb thermometers.

The phenomenon of the dew-point may be illustrated by reference to the affairs of common life. A bottle of wine, to be rendered more agreeable, has been iced before its appearance in the dining-room. You will find that the bottle will be covered with a coating of dew the moment it enters the room; the temperature of its contents being far below the point of saturation, the watery vapour from the atmosphere will be condensed on the surface.—I visited some time since the observatory of a distinguished astronomical friend—every instrument in it was streaming with moisture. "The great drawback to my position," said he, "is the neighbourhood of yonder piece of water—see the effect." Upon inquiry, I learnt that, on the preceding evening, the observatory had been open; the instruments had been cooled down to the night temperature, and the day chancing to be much warmer than usual, they had not had time to get heated above the temperature of the dew-point, and the deposition of moisture was the result—a cause entirely distinct from the one alleged.

I have a building detached from my own residence, which for some short time last Christmas was left without a fire. On my entrance one morning, which happened to be warm after a very cold night, I found the walls covered with moisture: they had, in in fact, retained the temperature of the night, and the moisture was due to their not having acquired sufficient heat, in the short space of time elapsed, to exceed the temperature of the dew-point; moisture, therefore, could not but settle on them, which disappeared as soon as they had attained a degree of heat rising above it.

III.—*Register Thermometers.*

As it is not my intention to enter upon the theory of atmospheric phenomena, which might perhaps form the subject of a future paper, I must proceed to describe another necessary adjunct to a meteorological apparatus, namely—the Register Thermometer.

Automatic registration of atmospheric phenomena has engaged for some time the attention of scientific men. At the observatory of Brussels, M. Quetelet pointed out to me an elegant contrivance, by which a thermometer was made to record its own variations. It was suspended on its centre of gravity, so that at the freezing point it should hang perfectly horizontal. At any degree of heat above 32° Fahrenheit, or the zero of Reaumur, the expansion of the mercury caused a depression of the end of the instrument the farther from the bulb; whereas, below the freezing point, the metal would retreat towards the bulb, and that portion of the tube would be the heavier. The instrument was connected in an ingenious manner with a system of levers, one of which moved a black-lead pencil, which inscribed the variations of heat on a sheet of paper connected with clock-work, by which it was advanced equal spaces (about one inch each per hour), a new sheet being supplied every day. These sheets gave the minutest variation in the temperature during the twenty-four hours.

For the last two or three years the magnetical, barometrical, and thermometrical observations have been registered at Greenwich by the application of photography. A lamp directs its light to the instrument, which light is intercepted by the mercury, and prevented from leaving a trace on properly prepared photographic paper placed behind. This paper is wound on a cylinder, which is turned round by clock-work, and its indications form an accurate register of the changes which may have taken place. Mr. Brook received from Government the sum of 500*l.* for the skill and labour bestowed on bringing this method of registration to perfection. The members of the British Association for the advancement of Science will call to mind his papers on the subject, which he has moreover fully discussed in the 'Philosophical Transactions.' From the Greenwich Meterological Observations for 1847, the following account of its especial application to the dry and wet-bulb thermometer is extracted:—

"These thermometers are mounted under a shed 10 feet square, standing upon posts 9 feet high, and the centres of the bulbs are 4 feet above the ground. The bulbs of the thermometers are very large, being cylinders about 8 inches long, and 0·4 inches internal bore. The fluid is quicksilver. One of the thermometer bulbs is covered (in the usual way) with muslin, which is charged with water by capillary passage along lamp-wicks, connected sometimes with one and sometimes with three cisterns of water. There is a coarse screw-motion for raising or depressing the thermometer-frames, so that each can be placed in such a position with regard to the photographic paper that the temperature shown by the thermometer may be recorded upon a convenient part of the paper. The thermometer-frames are covered by plates having longitudinal apertures, so narrow that any light which may pass through them is completely, or almost completely, intercepted by the broad flat column of quicksilver in the thermometer-stalk. Across these plates a fine wire is placed at every degree; and at the decades of the degrees, and also at 32°, 52°, and 72°, a coarser wire is placed. A camphine lamp (which has however been lately displaced for gas mixed with the vapour of coal naphtha) is placed near to each thermometer, and its light, condensed by a cylindrical lens whose axis is vertical, shines through the thermometer-stalk above the surface of the quicksilver, and forms a well-defined line of light upon the cylinder of paper which is close to it, parallel to the axis of the cylinder. As the cylinder of paper revolves under this light, it leaves a broad sheet of photographic trace, whose breadth (in the direction of the axis) varies with the varying height of the quicksilver in the thermometer-tube. But the light is intercepted by the wires placed across the tube at every degree; and there are, therefore, left upon the paper corresponding lines, in which there is no photogenic action." It is found that the application of photographic registration has enabled two observers to record more valuable observations than four were able to do before its introduction.

Private observers, however, cannot be expected to procure the costly apparatus necessary for these elaborate records. The maximum and minimum thermometers invented by Dr. John Rutherford, and described in the 'Edin. Phil. Trans.,' Vol. III., will enable them to record the greatest heat during the day, and the least during the night, with great certainty and very little trouble. The maximum thermometer is mercurial, and the tube is in a horizontal position; the mercury, as it expands, drives before it an index of steel, which, as the mercury contracts, is left at a point which indicates the greatest degree of heat attained. This thermometer is usually read at 9 A.M., and the index is brought to touch the mercury in preparation for the next day, either by inclining the tube, or by means of a magnet if it does not move freely. In some maximum thermometers a small piece of enamel is introduced between the index and the mercury, to prevent adhesion between the two metals, whereby the index would be drawn back and the observation lost. The minimum thermometer is filled with spirits of wine; a small index of ivory lies in the spirit, and is drawn backward as the liquid contracts in cooling, for the last film of the column of spirit, from the attraction between it and the interior of the tube, is sufficient to carry back the index towards the bulb: on expansion by heat the spirit, however, freely passes it, and leaves it to point out the lowest temperature attained. These thermometers should be compared with the dry bulb thermometers, by immersion in water as before described, and their readings, if they differ, registered and applied as corrections.

It has been usually supposed that a mean of the maximum and minimum readings for a month, divided by the number of days, would give the mean temperature for the month; but one of the contributions of Mr. Glaisher to meteorological science has shown that each month requires a certain quantity to be subtracted to arrive at the true mean.

He has also shown, that if to the mean of daily observations taken at any hour, certain quantities be added or subtracted, the mean temperature will be the result; it follows, that if the mean temperature thus deduced from one or more observations daily, agree with that derived for the corrected maxima and minima, such agreement is a proof of the excellency and a test of the accuracy of the whole series. (See the 'Phil. Trans.', Part I., 1848.)

In illustration I subjoin the result of my observations for January, 1849:—

Mean of the 9 A.M. observations for the month	40·7
Tabular correction	+ 1·
Mean temperature for the month	41·7
Mean of the 3 P.M. observations	44·1
Tabular correction	− 2·5
Mean temperature	41·6
Mean of the 9 P.M. observations	40·9
Tabular correction	+ ·4
Mean temperature	41·3

Mean of the above three results, 41·5.

Mean of the maximum readings for the month	45·1
Mean of the minimum readings	38·4
Arithmetical mean of these quantities	41·7
Tabular correction	− ·2
Mean temperature from the maxima and minima	41·5

which exactly agrees with that deduced from the observations at 9 A.M., 3 P.M, and 9 P.M., after the application of the proper corrections.

As this paper is devoted to the description of instruments and not to the theory of meteorology, I must forbear to enter further on these points: I have alluded to them sufficiently to show that there is a field of inquiry open for the curious and inquisitive, which will amply repay cultivation.

Some observers are in the habit of recording the highest reading of a thermometer exposed to the full force of the sun's rays. In this case the instrument is of glass, with the degrees marked on the tube itself, to prevent accumulation of heat, reflection, and radiation from a scale of wood or metal. It should be suspended at such a distance from all buildings and from the ground, as should effectually guard it from interferences of this nature. It will be a matter of surprise to those who have not had experience in observations of this nature, to find how very few degrees a thermometer thus situated will rise above one in the shade.

IV.—*The Rain-Gauge.*

This instrument measures the quantity of rain that falls in any given spot. The principle of it is the following:—If we imagine the surface of the ground over which a shower of rain has passed to be perfectly horizontal and impervious to moisture, so that the whole quantity of water should be retained, it would cover the surface to a certain depth, which, measured in inches, would be the depth of rain which had fallen. In calculating this depth by means of the rain-gauge, we expose a small surface to the reception of the rain, and measure the depth of what it receives. A shower may, however, pass by it, and, although much may fall at no great distance, not a drop may reach the exact spot occupied by the rain-gauge itself. Hence, to obtain the exact amount of rain which falls in any given district, several rain-gauges should be dispersed in various parts, and the mean of the whole amount received would be the true quantity due to such locality.

In this busy world of ours, however, observers (most of whom have important business of their own) are generally satisfied with registering the amount of rain received by their own gauges at 9 A.M. every day; and with the imperfect results deduced from these registers we must be satisfied, until a more extensive love for science is created and the number of observers multiplied.

Rain-gauges are of various constructions. In some, a glass tube, divided into inches, proceeds from the bottom of the vessel in which the rain is received, and the amount having been read off, the water is discharged by a stop-cock, in readiness for the next day. In others, a float is elevated by the water, and the scale which is attached to it shows the depth of rain received.

Perhaps the most simple is the one which I have adopted, and which is never liable to be out of order. A circular copper funnel, 12 inches diameter, is connected by a pipe with a vessel capable of holding a gallon, or more. To the bottom of this vessel is attached a stop-cock, by means of which the rain is drawn off and measured in a graduated glass cylindrical jar. Now, if a represent the diameter of the receiving vessel, and b that of the jar, c the depth of rain in the vessel, and x the required depth of the glass jar to measure such amount, then, since area, multiplied by the depth, gives the volume—

$$\cdot7854\,a^2c = \cdot7854\,b^2x; \qquad \text{or, } a^2c = b^2x.$$

Now, suppose the diameter of the glass jar to be 2 inches, and it is required to find what the depth of the jar will measure ¼-inch, we have—

$$12^2 \times \cdot25 = 2^2x; \qquad \text{or, } x = 9.$$

Nine inches of the jar, 2 inches in diameter, will therefore measure one-quarter of an inch of rain, received by a surface 12 inches in diameter. One twenty-fifth part of nine inches will consequently measure one-hundredth of an inch; and the thousandths may be estimated.

The rain-gauge should be only a few feet from the ground, and in every case its height should be stated, as it is invariably found that more rain is received near the surface than at a superior elevation. Indeed, it should be agreed upon by observers that their gauges should all be at the same height, and all equally free from the interference of buildings or trees. Till some rule of this kind is adopted, we are not in a position to compare accurately the quantity of rain which falls in different districts. At Greenwich there are several rain-gauges at different heights above the ground.

The following table will show the differences between the quantity of rain received by them in 1846 and 1847:—

Height above the ground. ft.	in.	Inches of rain received in 1846.	Inches of rain received in 1847.
50	0	13·46	7·12
24	0	22·63	13·02
1	11	25·86	16·49
0	5½	25·29	17·61

V.—*The Wind-Gauge.*

The most simple instrument for ascertaining the force of the wind, and the one most likely to be made use of by the generality of observers, is that invented by Dr. Lind. It consists of a glass tube, about ¼-inch in diameter, of a syphon-like form, one end being again bent at right angles to the general direction of the tube, so as to present a horizontal opening to the wind. The tube is half-filled with water, and the pressure of the wind on that portion directed towards it will drive the water up the other leg. A scale is attached, by which the force of the wind is ascertained; and the whole turns freely on a vertical axis, so that the mouth may always be towards the quarter from whence the wind blows. The following table shows the pressure per square foot for the indications of the scale.

Not having a convenient place to fix this instrument, for it should be far above the interference of buildings or trees, I generally estimate the force of the wind from the knowledge gained by its occasional use. Many observers do so without any reference to the wind-gauge at all; and from following the directions in the table subjoined, they cannot be far out. A calm is universally represented by 0; a hurricane, or violent gale, by 6.

TABLE.—*Showing the Force of the Wind on a Square Foot for different Heights of the Column of Water in "Lind's Wind-Gauge."*

Inches.	Force in lbs.	
6	31·75	A hurricane
5	26·04	A very great storm
4	20·83	A great storm
3	15·62	A storm
2	10·42	A very high wind
1	5·21	A high wind
·5	2·6	A brisk gale
·1	·52	A fresh breeze
·05	·26	A pleasant wind
0·	0·	A calm

It now only remains for me to speak of the position of the instruments which I have enumerated.

The barometer may be placed in a sitting-room; for as the correction for temperature is always applied, the degree of heat will produce no difference in the results. It should be so situated as regards light that it may be easily read off. To support the wet and dry bulb and register thermometers, I use a stand of such a height as to allow the bulbs to be about four feet from the ground; the top sides and back of this stand are covered with an external case of wood-work, separated from the internal, which is of the same materials, by a vacant space of two inches, by which means a stratum of air, which is a bad conductor of heat, is always interposed; and the heat of the sun which shines on the outer case is prevented from reaching the inner compartment which contains the thermometers; they face the north, and are placed so that they cannot be affected by the radiation of heat from neighbouring walls or buildings, and the sides of the stand project so as to protect them from the sun when his azimuth is north of the east or west. A series of holes, not however opposite to each other, is bored in the inner and outer case, which admit the air, but not the rays of the sun. Mr. Glaisher has shown, and his result may be verified by experiment, that the indications both of the wet and dry thermometers will be the same whether they are exposed to a draught of air or protected from it.

The following works must be procured by those who wish to become observers:—Glaisher's 'Hygrometrical Tables,' which treat of the wet and dry bulb thermometers, and the deductions from observations made with them, price 2*s.* 6*d.*

The 'Report of the Committee of Physics of the Royal Society;' here may be found a good table for the temperature correction, 1*s.*

Prices of the instruments enumerated: barometer, 7*l.* 7*s.*; wet and dry bulb thermometer, 2*l.* 2*s*; register thermometers, 2*l.* 2*s.*; rain gauge, 2*l*, 10*s.*; wind gauge, 1*l.* 5*s.* Mr. Clark, 13, Moorgate-street, will supply paper ruled in such a manner as to afford a convenient space for the record of all the observations.

I have thus given a popular view of the construction and use of the most available meteorological instruments, and shall be happy if my introduction of the subject should lead to a large increase of the number of observers. About forty at present send in regular reports to the Registrar-General; but let us hope that the present movement, of which the formation of the British Meteorological Society is the indication, may enlist ten times that number, and that the labours of its members may tend to raise the study of atmospheric phenomena to a position equal to that held by sciences which have originated in our time. The observations require care, perseverance, and a desire to promote the interests of science.

We know not, perhaps, the exact end which may be attained by our individual labour; but hereafter it will be a source of satisfaction to consider that we have been humble pioneers in a region which may be productive of benefits at present unimagined and unforeseen.

Southampton, May 18*th*, 1850.

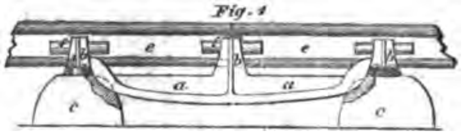
REGISTER OF NEW PATENTS.

RAILWAY CHAIRS.

John Torkington, of Bury, Lancaster, railway contractor, for "*certain improvements in the construction of chairs for railways.*"—Granted October 12, 1849; Enrolled April 12, 1850. [Reported in *Newton's London Journal.*]

The object of this invention is to obviate the serious inconveniences which result from the yielding of the rails at the joinings or points where the different lengths of rail meet or cross, during the passage of trains over the same; and it consists in certain improvements in the chairs used for supporting such rails, whereby the patentee produces what he calls the "uniformly-supporting joint chair."—Fig. 1 is a longitudinal elevation of the improved chair; fig. 2 is a plan view thereof; fig. 3 is an end view; and fig. 4 is a transverse section taken at the centre of the chair. It consists of an iron rib or beam *a*, about three feet long, on the upper side of which three holders or chairs *b*, *b*, b^1, similar in form to the ordinary chairs, are cast; and the rib or beam rests at each end upon a transverse sleeper *c*, to which it is secured by spikes or trenails *d*, *d*. The top of the rib or beam serves to support the ends of the two adjacent rails *e*, e^1, which meet at the centre of the middle holder or chair *b*, and are secured there by the insertion of a key or wedge *f*; and similar keys or wedges are driven into the two end holders or chairs *b*, *b*: the bearing of the ends of the rails on the chair, which now seldom exceeds two inches, is thus increased to about eighteen; and there will consequently be a proportionate increase in the unyieldingness of the rails under pressure and in the steadiness of the carriages passing over them. This arrangement is stated to combine all the advantages of the longitudinal system of laying sleepers with those resulting from the employment of transverse sleepers or blocks. Instead of the holders or chairs *b*, being cast in one piece with the rib or beam *a*, they may be cast separately, and afterwards secured thereto by inserting their bases (which are suitably formed for the purpose) into dovetail recesses in the top of the rib or beam, and then driving in the wedges *g*. In place of only three holders or chairs being cast on or attached to the rib or beam *a*, the number may be increased to five.

Fig. 1



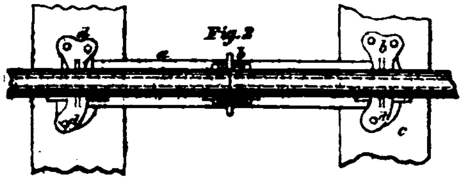


Fig. 4

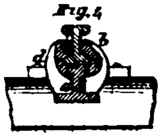
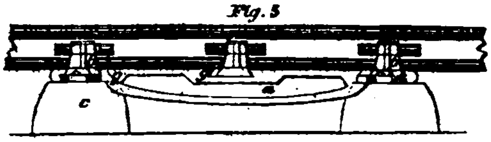


Fig. 3

Fig. 5



BOILER TUBES.

James Bannister, of Birmingham, manufacturer, for "*a certain improvement or certain improvements in tubes for locomotive and other boilers.*"—Granted October 12, 1849; Enrolled April 12, 1850.

The invention relates to manufacturing tubes suitable for locomotive and other boilers, by combining three tubes of different metals into one tube; and to a mode of manufacturing tubes of copper, brass, and other alloys of copper, suitable for the purposes of locomotive and other steam-boilers. In the first part of the invention for making each tube, three tubes of different metals are employed. First, a brass tube; second, an iron tube; and, third, a copper tube, are placed one on the other, the brass tube being on the interior; the iron tube next; and the copper tube exterior; and in preparing such separate tubes they are made of such sizes that they will readily enter one within the other. Brazed tubes are preferred, because thin metal tubes for the purpose can be more readily obtained. Having placed the tubes one on the other, a slightly tapering mandril is introduced, and the combined tube drawn through a series of dies till they are closely combined; and as the tubes are employed in a soft or annealed state when put together, it has not been found necessary to anneal them afterwards between the successive processes of drawing, seeing that the extent of drawing down is but small. By this mode of constructing tubes for boilers the advantage is obtained of having the beneficial results consequent on using brass where the rush of the flame and products from the fire takes place, together with the advantage of having the copper next the water; and the whole stiffened by the use of iron; but when the fire is to act externally, then the order of arrangement is to be reversed.

The second part of the invention consists of new means of joining the seams of tubes made of copper or brass and other alloys of copper. The metal is to be bent over into the form of a tube, so that the edges come together, and then, by the edge of a triangular file remove the edges of the metal, so as to form as it were an angular gutter. The tube is then filled with sand, and the exterior covered with sand, leaving a gutter in the sand so as to increase the size of the gutter made by the coming together of the chamfered edges of the metal, and in this condition the tube is heated to a bright red heat. Melted metal (similar to that used for the tube) is then poured into the gutter, which will partially fuse the edges of the metal of the tube, and then the whole will set into a solid mass; and when the same is cold the projecting-ridge of metal at the seam is removed; and this is best done by passing it in contact with a circular saw. The tubes thus made are caused to pass two or three times through between grooved rollers, having a mandril in them, and then they are completed by drawing them through dies with a mandril, as when drawing other similar tubes for like purposes, and which is well understood.

MANUFACTURE OF STEEL.

Josiah Marshall Heath, of Hanwell, Middlesex, gentleman, for "*improvements in the manufacture of steel.*"—Granted September 6, 1849; Enrolled March 6, 1850.

The invention consists in the application of iron, produced from iron ores without being brought to the state of pig or cast-iron, to the manufacture of steel, the iron so produced being manufactured by the process described, which renders it more suitable for conversion into steel than any iron hitherto made by the processes actually in use. The excellence of the steel depends upon the comparative purity or freedom from mixture with extraneous substances of the iron from which it is made. All iron made by smelting the ores of that metal in a blast furnace contains impurities, in consequence of the alloys formed between the fluid metal and the earthy alkaline or other extraneous substances contained in the ores, the fuel, and the matters used to flux the ores. These impurities can never be completely removed from the metal by the operations in use for converting the pig into malleable iron.

Any pure ore or oxide of iron from which the earthy or other extraneous matters can be easily separated by the mechanical operations of crushing, winnowing, washing, or magnetic attraction, may be treated in the manner the inventor proposes, but he prefers the magnetic ore of iron to all others. The ore is to be reduced to the state of grains, or even of fine powder, in order to facilitate the separation from it of the earthy or other extraneous substances; the pure ore is then to be reduced to the metallic state by any of the well-known processes for depriving the metal of oxygen, by acting upon it with carbon, or any other reducing agent at a heat below that required to bring the metal to the fluid state. The metallic product obtained in this way, when operating upon a manufacturing scale, can never be obtained absolutely free from the last portions of earthy or other impurity, and always contains some portion of oxide of iron, which renders it quite unfit for conversion into steel of good quality, as it comes from the process of deoxidation without further treatment.

To make a perfect steel iron, the metallic product is taken as it comes from the process of cementation or deoxidation, and mixed with a small portion of oxide, or chloride of manganese, and a certain portion of coal or fir tar, or any cheap hydrocarbon or carbonaceous matter. The best results are obtained from the mixture of from one to three pounds of oxide or chloride of manganese, and from one to two gallons of coal or other tar to each one hundred pounds of deoxidated ore. The mixture of granular iron tar and manganese, resulting from this process, is heated in a suitable furnace; and when the iron is at a welding heat it is removed from the furnace, and subjected to the action of some suitable instrument of compression, in order to be formed into a solid bloom by any of the usual processes now in use. The bloom is then to be reheated and shingled, hammered, or rolled into bars in the usual manner. The bar-iron so produced is to be converted into steel by the well-known processes now in use, and its quality will be found superior to that made from the best iron hitherto procurable.

VITRIFIED BRICKS.

William Gilbert Elliott, of Blisworth, Northampton, gentleman, for "*improvements in the manufacture of bricks, tiles, and pipes, and other articles from plastic materials.* (A communication.)—Granted April 27; Enrolled May 27, 1850.

This invention relates to manufacturing bricks, tiles, pipes, and other articles, from clay, melted or fused, and run into moulds of the shape of the articles required to be produced. The clay, as it is dug from the pit, if dry, is conveyed to an air or blast furnace, wherein it is brought to a state of fusion, and then run into the moulds, which should be as close to the furnace as possible; for the melted clay should be introduced into the moulds at a high degree of heat; as it will not bear to be conveyed in ladles or run through troughs into the moulds. The moulds may be made of iron or other suitable material. The moulds may be carried to and from the furnace by an endless wire web or band, which moves beneath the furnace, and thus brings the moulds close to the opening from which the fused clay is discharged.

GLAZING CAST-IRON.

William Wyatt, of Waterloo Cottage, Oldswinford, Worcester, pump-maker, for "*improvements in coating the surfaces of pumps, pipes, cisterns, and other articles of iron.*"—Granted October 18, 1849; Enrolled April 18, 1850.

The improvement relates to coating cast-iron pumps, cast-iron pipes, cast-iron cisterns, and other articles of cast-iron, with a glass or glaze composed of lead, borax, and silex, combined in the proportion of three parts, by weight, of white lead (or one of red lead and two of white lead), two parts of borax, and one part of calcined flint, well mixed together and fused in a crucible, then run into water, and ground with water in a glaze-mill. When the mixture is thoroughly reduced, so that it will readily pass through a silk or lawn sieve, such as are used by china manufacturers, it will be ready for use: it is not absolutely necessary to fuse the materials, but it is better to do so. The glaze thus prepared being about the consistence of cream, is applied to the inner surfaces of the pump-barrels, pipes, and similar articles of cast-iron, by closing one end, introducing a quantity of glaze, turning the article round, so as to coat the interior uniformly with the glaze, and then pouring out the surplus. The interior of cisterns and like articles of cast iron is coated in a similar manner, by introducing a quantity of glaze and moving the article about in various directions until the interior is uniformly coated. In general it will only be necessary to scour and wash the surface previous to coating; but if the surface is much oxidised, it is requisite to subject the articles to a red heat, and, when cool, to scour them well with water. It is preferred to warm the metal before the application of the glaze, in order to facilitate the drying of the latter. The exterior surfaces of articles of cast-iron may be coated by dipping the articles into the semi-fluid glaze, or by applying the glaze thereto with a brush.

After the pumps, pipes, cisterns, or other articles of cast-iron have received a coating of glaze, they are to be subjected to a suitable temperature for firing the glaze and thereby causing it to adhere. This is effected by placing the articles in a kiln heated in such manner that no flame or sulphur shall come in contact with the articles. The heat is gradually raised until the glaze melts (which can be seen by taking out a brick from an opening in the kiln); and, so soon as the melting of the glaze takes place, the fires are drawn, and the articles are allowed to cool: when the articles have become cool, they are removed from the kiln, and are ready for use.

REVIEWS.

Practical Ventilation, as applied to Public, Domestic, and Agricultural Structures. By Robert Scott Burn, Engineer. Blackwood and Sons, Edinburgh and London. 1850.

The importance of ventilation in connection with sanitary progress is an admitted fact, that does not require us now to descant upon. What has to be considered is, how ventilation may be applied to buildings effectively and economically; it is to these considerations that the author has devoted his attention. Mr. Burn first points out the necessity and importance of ventilation; and next shows how it may be applied to public buildings, and observes, that

"Natural ventilation does not depend upon machinery for its results, but is 'a process by which movements are induced or sustained in the air, in the same manner as wind is produced in the external atmosphere.' The *rationale* of natural ventilation cannot be better described than in the words of Dr. Reid: 'The specific gravity of air vitiated by respiration and combustion, the two great processes that deteriorate air in ordinary buildings, is under ordinary circumstances less than that of common air: it gives way accordingly, and is pressed upwards by the denser and purer air. Let us imagine, then, an apartment occupied by a number of persons standing on a porous floor, and the roof taken off; at ordinary temperatures, the air, vitiated there by the human frame, requires no mechanical power to remove it. The superincumbent pressure is diminished by the expansion induced in the air as it is heated; but the external air is permitted to have free access below, as well as above, to the porous floor. Its power therefore preponderates, and an upward movement is the necessary consequence; which is accompanied by the introduction of fresh air and the removal of that which is vitiated. Here, then, is a species of natural ventilation. All that is essential is merely this, that the natural movements induced by the heat of the body shall not be stopped by any barrier opposed to them. An open roof and ceiling is, however, inadmissible: protection is required from the weather, independent of other arrangements. The opening, accordingly, may be contracted: in proportion to the amount of contraction, the temperature of the air, and the numbers on a given space, it now becomes necessary to increase the velocity of the discharge from the apartment referred to. To effect this, if a shaft or chimney be extended from any opening in or near the ceiling, the column of warm air which soon fills it increases its power; and unless an extreme number of individuals be crowded in the apartments, the shaft *is sufficient for all ordinary purposes.*'

"In ventilating buildings, two things should be borne in mind; and as upon the proper attention to these depends the success of the plan, particular attention should be taken to see them carried into effect. These are, the supply of the interior with fresh air, and the withdrawing of it when vitiated. And here we would request attention to the fact, of which the evidence of all experience goes to prove the truth—that no *foul air can by any possibility be extracted from the interior of any building, however well arranged the means to insure its exit may be, unless an ample supply of pure air is admitted.* In making provisions for the supply of pure air, due regard should be had to the source from which it is supplied. If much dust or extraneous mechanical impurities should be at the base of the building, or drains near to or passing through there, the air should be led from a distance from the ground....And in order to stop the ingress of all extraneous particles of dust, &c. through the ventilator, there should be stretched across the *inside* of the opening, sheets of very finely perforated zinc or horse-hair cloth. Where the air has to be led into the interior of a church, say to the passages, ventiducts must be employed to conduct the air to the required place. These conduits may be made of zinc or iron pipes; but a cheaper mode is to make wooden boxes of sufficient size. To prevent the damp from affecting these, the outside should be covered with two or three coats of a composition of tar and sand (three of the former to one of the latter). The best place, in the generality of churches, to lead the air to, is the passages; and, indeed, in most other public buildings. The apertures at the place of ingress to the interior should be covered with cast-iron gratings. But in order to diffuse the air as much as possible in its passage through the gratings, along the under side of these, plates of zinc, with small perforations, should be fixed, or sheets of horse-hair cloth. For this purpose we would also recommend the adoption of "cocoa-nut fibre matting"—it is very cheap, porous, and can be made of any closeness of texture: it is becoming much used for the passages and aisles of churches. If used in this way, any species of grating, however rough, would do, as it would be hidden by the cloth laid above it. One thing in connection with the gratings should be borne in mind, that is, to have the apertures greater, at least equal in surface to those on the outside.

"The apertures for the admission of fresh air should be disposed at equal distances round the building, if possible on all sides, so that, from whatever quarter the wind blows, an aperture may be placed so as to receive its influence: not that the force of the wind is necessary, for air, as we have shown, will find its way wherever it is required, unless prevented; but in windy weather more air will be *forced* in, in a given time, than in calm weather. Having provided means for the admission of fresh, we will now direct attention to the means for withdrawing the foul air. The apertures for its escape should be placed in all cases at the highest part of the ceiling. If the nature of the building will admit of it, the area of the aperture should be distributed over the ceiling in more than one place. Supposing the area of aperture of a church is required to be 3 square feet—if three apertures of 1 square foot each, be placed along the roof at regular intervals, the building will be more speedily ventilated than if one aperture of 3 feet square was alone used."

In the next chapter the author explains how ventilation may be applied to dwelling-houses and shops, and describes several kinds of ventilators which are applicable to the purpose—such as Bailley's glass louvres, perforated glass, Dr. Arnott's valve, and Mr. Toynbee's suspension valve, consisting of a square iron tube, 3 to 6 inches square, and 4 to 6 inches long, with a piece of perforated zinc over the external orifice, and at the back a piece of oiled silk, which acts as a valve, so as to allow the warm and vitiated air to pass up the chimney, and to prevent any smoke entering the chamber.

Mr. Burn describes a method of ventilating a house by the staircase; it is simple, and appears to be very effective.

"In supplying fresh air to the lobbies, halls, or central staircases of large mansions, from which all the apartments are to be supplied, care should be taken to have the quantity sufficient in volume. It will materially assist the ventilation if the air is warmed as it is admitted. The air should be led to the floor of the hall, in which apertures may be made to allow it to pass through; or it may be taken to the back of the skirting, or beneath permanently fixed tables, the fronts of which should have plates of perforated zinc. If the staircase is provided with a skylight, this should be kept carefully closed; the desideratum, in such cases as we are now considering being to supply each apartment with means of withdrawing the used air, so as to draw their supply of pure air from the central magazine; not only ventilating themselves, but also the staircases, passages, &c., these being supplied with fresh air from the central magazine. If the skylight was left open, thus creating a powerful upward current, the flow of air into the apartments would be materially retarded, if not in some cases altogether stopped. There is one danger connected with this plan of supplying air to the apartments of large mansions, worth being noticed; this is if each apartment is not properly ventilated, the foul air from it will obtain access to the central magazine whenever the door is opened, its egress through such being easier—the air in the central magazine being thus contaminated. Again, some apartments may, from more powerful ventilating arrangements, draw their supply from another apartment; this shows the necessity of having the supply to the central magazine ample. If the mansion consists of many stories, each landing may be supplied with a separate supply of pure air, independent of the openings in the hall previously mentioned."

In the next chapter, Mr. Burn explains how ventilation may be applied to agricultural structures; and in the concluding chapter, various systems of warming of buildings, construction of fire-places, and smoky chimneys. Here we must stop, before we are tempted to make a few more extracts, as we have already intruded further than we at first intended upon the work.

A Rudimentary Treatise on the History, Construction, and Illumination of Lighthouses. By Alan Stevenson, M. Inst. C.E., Engineer to the Board of Northern Lighthouses. London: Weale. 1850.

It must certainly be esteemed a great recommendation for this rudimentary treatise that it is written by the constructor of one of the greatest lighthouses in the world—that at Skerryvore. Mr. Stevenson is the author of a description of this work, and therein has laid the foundation of the present treatise, which applies to lighthouses generally those principles which were discussed before in especial reference to Skerryvore. Much space is given to the various systems of illumination adopted; and of the remainder of the book, although most valuable, it is so well known we are almost deterred from making a quotation. At all risks, however, we give some account of Skerryvore.

"The Skerryvore Rocks, which lie about 12 miles w.s.w. of the seaward point of the Isle of Tyree, in Argyllshire, were long known as a terror to mariners, owing to the numerous shipwrecks, fatal alike to the vessels and the crews, which had occurred in their neighbourhood. A list, confessedly incomplete, enumerates thirty vessels lost in the forty years preceding 1844; but how many others, which during that period had been reported as "foundered at sea," or as to whose fate not even an opinion has been hazarded, may have been wrecked on this dangerous reef, which lies so much in the track of the shipping of Liverpool and the Clyde, it would be vain to conjecture. The Commissioners of the Northern Lighthouses had for many years entertained the project of erecting a lighthouse on the Skerryvore; and with this object had visited it, more especially in the year 1814, in company with Sir Walter Scott, who, in his diary, gives a graphic description of its inhospitable aspect. The great difficulty of landing on the rock, which is worn smooth by the continual beat of Atlantic waves which rise with undiminished power from the deep water near it, held out no cheering prospect; and it was not until the year 1834, when a minute survey of the reef was ordered by the Board, that the idea of commencing this formidable work was seriously embraced.

"The reef is composed of numerous rocks, stretching over a surface of nearly 8 miles from w.s.w. to e.n.e. The main *nucleus*, which alone presents sufficient surface for the base of a lighthouse, is nearly 3 miles from the seaward end of the cluster. It is composed of a very compact *gneiss*, worn smooth as glass by the incessant play of the waters, and is so small that at high water little remains around the base of the tower but a narrow band of a few feet in width, and some rugged humps of rock, separated by gullies through which the sea plays almost incessantly. The cutting of the foundation for the tower in this irregular flinty mass occupied nearly two summers; and the blasting of the rock in so narrow a space, without any shelter from the risk of flying splinters, was attended with much hazard.

"In such a situation as that of Skerryvore everything was to be provided beforehand and transported from a distance; and the omission in the list of wants of even a little clay for the *tamping* of the mine-holes, might for a time have entirely stopped the works. Barracks were to be built at the workyard in the neighbouring island of Tyree, and also in the Isle of Mull, where the granite for the tower was quarried. Piers were also built in Mull and Tyree for the shipment and landing of materials; and at the latter place a harbour or basin, with a reservoir and sluices for scouring the entrance, were formed for the accommodation of the small vessel which attends the lighthouse. It was, besides, found necessary, in order to expedite the transport of the building materials from Tyree and Mull to Skerryvore Rock, to build a steam-tug, which also served in the early stages of the work as a floating barrack for the workmen. In that branch of the service she ran many risks while she lay moored off the rock in a perilous anchorage, with *two-thirds* of the horizon of *foul ground*, and a rocky and deceitful bottom on which the anchor often *tripped*.

"The operations at Skerryvore were commenced in the summer of 1838, by placing on the rock a wooden barrack, similar to that first used by Mr. Robert Stevenson at the Bell Rock. The framework was erected in the course of the season on a part of the rock as far removed as possible from the proposed foundation of the lighthouse tower; but in the great gale which occurred on the night of the 3rd of November following, it was entirely destroyed and swept from the rock, nothing remaining to point out its site but a few broken and twisted iron stancheons, and attached to one of them a piece of a beam so *shaken* and rent by dashing against the rock as literally to resemble a bunch of laths. Thus did one night obliterate the traces of a season's toil, and blast the hopes which the workmen fondly cherished of a stable dwelling on the rock, and of refuge from the miseries of sea-sickness, which the experience of the season had taught many of them to dread more than death itself. After the removal of the roughest part of the foundation of the tower had been nearly completed, during almost two entire seasons, by the party of men who lived on board the vessel while she lay moored off the rock, a second and successful attempt was made to place a second beacon of the same description, but strengthened by a few additional iron ties and a centre post, in a part of the rock less exposed to the breach of the heaviest waves than the site of the first barrack had been. This second house braved the storm for several years after the works were finished, when it was taken town and removed from the rock to prevent any injury from its sudden destruction by the waves. Perched 40 feet above the wave-beaten rock in this singular abode, the writer of this little volume, with a goodly company of thirty men, has spent many a weary day and night at those times when the sea prevented any one going down to the rock, anxiously looking for supplies from the shore, and earnestly longing for a change of weather favourable to the recommencement of the works. For miles around nothing could be seen but white foaming breakers, and nothing heard but howling winds and lashing waves. At such seasons much of our time was spent in bed; for there alone we had effectual shelter from the winds and spray which searched every cranny in the walls of the barrack. Our slumbers, too, were at times fearfully interrupted by the sudden pouring of the sea over the roof, the rocking of the house on its pillars, and the spurting of water through the seams of the doors and windows, symptoms which, to one suddenly aroused from sound sleep recalled the appalling fate of the former barrack, which had been engulphed in the foam not twenty yards from our dwelling, and for a moment seemed to summon us to a similar fate. On two occasions, in particular, those sensations were so vivid as to cause almost every one to spring out of bed; and some of the men fled from the barrack by a temporary gangway to the more stable but less comfortable shelter afforded by the bare wall of the lighthouse tower, then unfinished, where they spent the remainder of the night in the darkness and the cold.

"The design of the Skerryvore lighthouse was given by the writer of this volume, and was an adaptation of Smeaton's Eddystone Tower to the peculiar situation and circumstances of the case at the Skerryvore, with such modifications in the general arrangements and dimensions of the building, as the enlarged views of the importance of lighthouses which prevail at the present day seemed to call for.

"The Skerryvore Tower is 138 ft. 6 in. high, and 42 feet in diameter at the base, and 16 feet at the top. It contains a mass of stonework of about 58,580 cubic feet, or more than *double* that of the Bell Rock, and not much less than *five times* that of the Eddystone.

"The mortar used at the Skerryvore was compounded of equal parts of limestone (from the Halkin Mountain, near Holywell, in North Wales), burnt and ground at the works, and of Pozzolano earth. The mixture was carefully beaten up to the required consistency with sea-water. All the joints of each course of the building were carefully filled with *grout*, which is cement in a fluid state.

"The entire cost of the lighthouse, including the purchase of the steam vessel and the building of the harbour at Hynish for the reception of the small vessel which now attends the lighthouse, was 86,977*l.* 17*s.* 7*d.*, the detailed items of which will be found in the Appendix to the *Account* of the Lighthouse already alluded to.

"In such a situation as the Skerryvore, innumerable delays and disappointments were to be expected by those engaged in the work; and the entire loss of the fruit of the first season's labour in the course of a few hours, was a good lesson in the school of patience, and of trust in something better than an arm of flesh. During our progress, also, cranes and other materials were swept away by the waves; vessels were driven by sudden gales to seek shelter at a distance from the rocky shores of Mull and Tyree; and the workmen were left on the rock desponding and idle, and destitute of many of the comforts with which a more roomy and sheltered dwelling and the neighbourhood of friends are generally connected. Daily risks were run in landing on the rock in a heavy surf, in blasting the splintery gneiss, or by the falling of heavy bodies from the tower on the narrow space below, to which so many persons were necessarily confined. Yet had we not any loss of either life or limb; and although our labours were prolonged from dawn to night, and our provisions were chiefly salt, the health of the people, with the exception of a few slight cases of dysentery, was generally good throughout the six successive summers of our sojourn on the rock. The close of the work was welcomed with thankfulness by all engaged in it; and our remarkable preservation was viewed, even by many of the most thoughtless, as, in a peculiar manner, the gracious work of Him by whom 'the very hairs of our heads are all numbered.'"

Architectural Publication Society. Illustrations, Part II. of Volume for 1849-50.

The part now before us includes Arcade, Mosaic Ceiling, Interior of Chapels, Chimney, Façade, Metal Work, Pedestal, Piazza, Pulpit, and Staircase, with thirteen plates. Most of the examples are Italian. The plate representing the interior of the Chapel of San Domenico at Bologna is coloured so as to give some idea of the picturesque appearance of the original building. The Mosaic Ceiling of the Sacristy of St. Mark's at Venice is a novelty, and it is likewise illustrated by an illuminated plate of a portion, gorgeous in its effect. The plate of Lombard Chimnies gives one-and-twenty varied designs. The article Façade shows two arcaded buildings. There is likewise a Flemish brick front in the Gothic style. The Metal Work gives some picturesque knockers.

Attached to this part is some description of the buildings represented in the two parts of the volume for this year.

Buildings and Monuments, Modern and Mediæval. Edited by George Godwin, F.R.S. London: 1850. Part VII.

The church of the Immaculate Conception, by Mr. Scoles, exhibits some very rich tracery; the church of La Villette, at Paris, is interesting, as showing how parish churches are treated there; the Custom-house, Rouen, is a novel piece of street architecture. There are likewise other subjects, and as some details are given, the number will be a very acceptable addition to the library.

Sections of the London Strata. By Robert W. Mylne, C.E. F.G.S., F.S.A., M. I.B.A. London: James Wyld. 1850.

Mr. Mylne's work, no doubt, will meet with its full share of favour, it being particularly useful to all who are engaged or interested in the sanitary progress of the metropolis. There are five sections; the first alone has the strata delineated in detail, with the necessary geological references: the remaining four sections are only in outline; but as the author intends to complete them from materials already collected, the horizontal and vertical scales are in the proportion of 18 to 1. The engravings also show the site and depth of all the principal wells which have been sunk in and about London. We hope this work will induce other engineers and architects to observe and describe the structure of the country around them, for at present our knowledge of the crust of the earth is very inaccurate and limited.

Hydraulic Tables. By Nathaniel Beardmore, M. Inst. C.E. London: Waterlow. 1850.

Hydraulic engineering is so extensively practised as to require a considerable number of works for its practitioners; and Mr. Beardmore has rendered a very essential service by the publication of this hand-book, which in a very close compass gives the materials requisite for the calculation of water and mill-power, water supply, drainage, and the navigation of rivers, tables of the rainfall in England, and some subsidiary information. From Mr. Beardmore's experience and high-standing, we should have been prepared for a more extensive work, and more copious information.

The Civil Engineer's and Surveyor's Companion, and Assistant in Setting out Slopes, &c. By Edward Ryde, Surveyor. London: Published by the Author, 1850.

These pages constitute a set of tables for setting out slopes, curves, cuttings, and embankments, and as they are intended to save labour to professional men, will be welcomed. There is one part of Mr. Ryde's labours which might have been better applied: he has given his relative proportions in chains horizontally, and feet vertically; instead of this it would have been better had he taken the foot measure instead of the link, both horizontally and vertically. It has been found practically better to use the 100 feet chain instead of the 100 links in setting out railway works.

Architectural Sketches, Italy. By T. C. TINKLER, Architect.

The number now before us gives several details of the Villa Madama, near Rome, lately destroyed by the French: they chiefly exemplify a loggia. The Villa Borghese, though sketched on a small scale, is very picturesquely shown. Bits from the Campagna are sketches of several country buildings, showing the general effect and arrangements, and are of some interest.

Drawing from Objects. By HANNAH BOLTON. London: Groombridge. 1850.

This is a work founded on the system of drawing from common geometrical forms, which is now so prevalent in this country, and in which the writer has had much experience, having taught, in the last six years, nearly two thousand pupils, many of them teachers of national and infant schools. For a work of this kind it is well carried out, and in a liberal spirit; but we adhere to the opinion that it is better to begin with natural objects, instead of the stiff forms taken from conventional geometry.

The Telotype—a Printing Electric Telegraph. By FRANCIS GALTON, Esq., M.A. London: Weale. 1850.

This pamphlet describes at length Mr. Galton's invention, the object of which is to print messages in the ordinary alphabetical characters, and for which many ingenious contrivances are introduced. As the plan requires several engravings for its explanation, we are unable to compass it in a short description.

WATER SUPPLY FOR LIVERPOOL.

REPORT OF ROBERT STEPHENSON, C.E., *on the Supply of Water to the Town of Liverpool.*

(*Continued from page* 193.)

I now proceed to answer the first question in the Minute of January, 14, viz.—

> "*Whether a supply sufficient, as regards quantity and quality, for the present and prospective wants of the town and neighbourhood, including domestic, trading, and manufacturing purposes, and shipping, and for public purposes—viz., watering and cleansing streets, flushing sewers, extinguishing fires, and supplying public baths and wash-houses, can be obtained by additional boring or tunnels, or otherwise, at the present stations—viz., those purchased from the Companies respectively, and from the Green Lane Works, now vested in the Corporation, and the cost of obtaining such sufficient supply?*"

It is, I believe, admitted that the population at Liverpool to be supplied with water is about 400,000, and that an efficient supply for large towns is not less than twenty gallons per individual daily; thus the total quantity required at the present time is 8,000,000 gallons a-day. In the Report made by the Health of Towns Commissioners, it is stated that the increase of inhabitants in Liverpool was, for the ten years between 1831 and 1841, 39.6 per cent.; we shall probably, therefore, not err much in supposing the population to be supplied in 1861 will be 557,500, and the necessary quantity of water consequently augmented to 11,150,000 gallons a-day. But, in the first place, I shall consider the various schemes which have come before me in reference to a population requiring 8,000,000 gallons only.

My experiments to determine the yield of the wells are detailed in several tables of the Appendix, No. 1 of which gives those made to ascertain the effect of one stroke of the pump at each station; and, as the correctness of the final results depended on the accuracy of this element, much time and labour were given to the subject. Implicit reliance may therefore be placed on the experiments, which were made by discharging the water from the pump alternately into two tanks of known capacity (one being emptied while the other was being filled), and repeating this operation for a considerable length of time. The total quantity of water thus measured, divided by the number of strokes, of course gives the content of one stroke. The pumps, buckets, and clacks were tried in various conditions and under different pressures of water, and the utmost care was taken to secure the same relative conditions throughout the duration of the experiments, so as to obtain both the delivery of each stroke and the yield of the well.

At the Windsor station, where the engine was single-acting and the length of stroke variable, an apparatus was applied for the purpose of registering the exact distance passed through by the pump-rod; and, by reading the index of this instrument, and taking the number of strokes as given by the counter, the average length of stroke for any period was ascertained; and thus the total quantity of water discharged accurately determined. It was intended to have used this instrument at Green Lane also, but as it was required at Windsor to measure the increased yield during the progress of the boring, this could not be done. The yield of the Green Lane well was in consequence ascertained by proving the delivery of the pump, when working at a known length of stroke, by means of the tanks, and afterwards confining the length of stroke, throughout the subsequent experiments, as nearly as practicable to the same standard. The yield of the well at Bevington Bush, and the delivery of the pumps at the Bootle Station, were determined by pumping into a reservoir of known capacity and regular shape, at Kirkdale.

Table No. 2 shows the yield of each of the wells at various levels; Table No. 2 A the maximum yield; and Table No. 2 B the yield at the working levels of the last quarter of 1849, as proved both by the Dip-books and by my series of experiments.

These tables show that the maximum yield of all the wells in the possession of the Corporation amounts to 5,170,186, the minimum yield to 3,320,990, and the yield at the ordinary working level to 4,216,784 gallons per 24 hours. This, as recorded in the Dip-book, shows at corresponding levels a delivery of 3,834,758 gallons, which is as close an approximation as could be looked for. Mr. Hocking reported to Messrs. Simpson and Newlands that the yield of the wells was 4,220,969 gallons in April, 1849, but as the weekly produce is divided by six instead of seven, this amount ought to be 3,677,972 gallons. From all these results it may be inferred that the existing wells are yielding about 4,000,000 gallons a-day.

After the full explanation, in the preceding pages of this report, respecting the action of wells on each other, and the mode by which the water is transmitted throughout the body of the sandstone, it will at once be perceived that the expectation of much augmenting the supply of the present wells, either by sinking, boring, or tunnelling, cannot be entertained.

I am satisfied that any increase occasioned by deepening these wells will be temporary, and only take place to the same extent as the private supply of water is diminished. This would necessarily lead to the deepening of the private wells, which has already been done to a considerable degree; and when finished, would leave all parties in the same relative positions, except that they would have the same quantity of water, or a very little more to lift a greater height; and it cannot be doubted that a large proportion of any increase would be derived from the River Mersey, as all the wells are now sunk to or below the level of low water, and many yield brackish water.

Another theory of Mr. Gage may be here specially referred to. It seems to be that the water flows into wells from beneath, and is made to do so entirely from statical pressure, acting at a great distance and elevation; but the ascertained levels of the water in the sandstone and wells are to me totally irreconcileable with this notion, for if the pressure upwards which he supposes to exist were really operative, the level of the water in the sandstone ought to be uniform or very nearly so, which is certainly not the case. In the first exposition of his views he stated that the water flows through large fissures with comparative freedom, and supported this by pointing out the specific chemical differences in the water from adjoining wells; but this is no proof of his correctness, as the sandstone itself is far from being of uniform composition, and may give rise to much variety in the constituents held in solution, while the character of the surface in the vicinity of the well may also influence the quality of the water in the sandstone. Could the probability that the supply of water is derived from the Welsh or Yorkshire hills in any way be imagined, the friction alone, which is an ascertainable quantity under known circumstances, would prevent the possibility of the rapid flow of the large quantity of which Mr. Gage predicts would be obtained by means of bore-holes.

The question of expense points to the propriety of diminishing rather than increasing the supply from the existing wells; indeed, the advantage of abandoning some of them has already been pointed out by Mr. Newlands, Mr. Kennedy, and others, and a Table is introduced into the Appendix, showing the costliness of the water at present obtained from all except Windsor and Green Lane, by which it would appear that their abandonment, and the establishment in their place of two new ones, similar to, or somewhat more extensive than Green Lane, would produce a saving of 3,992*l.* per annum on the working expenses, or enough to justify an expenditure on the new and more economical establishments of 80,000*l.*, in addition to the value of the land and works; whereas, the two stations would not cost more than about 56,000*l.*

Messrs. Simpson and Newlands' Scheme.

The second question contained in the Minute is,

> "*Whether a sufficient addition to the present supply can be obtained in the locality or neighbourhood of Liverpool, as recommended by Messrs. Simpson and Newlands. or by borings, or by any other course, and the cost of obtaining and distributing the same.*"

This question comprehends the plan now before parliament, which may be called the Newsham House Scheme; Messrs. Simpson and Newlands' Scheme, as described in their printed report of April 23rd, 1849; and Mr. Simpson's Kirkby or Clock House Bridge Scheme.

The Newsham House Scheme consists in making a well 192 feet deep, at a distance of about 590 yards from Green Lane Station, with 8 furlongs 248 feet of tunnel; a new engine and well of 150 feet deep, with 600 feet of tunnel at Bootle, and 1 furlong and 240 feet of tunnel from the bottom of the Windsor well.

After the free communication which has been proved to exist between the Green Lane well and those surrounding it, situated at much greater distances from each other than that proposed at the Newsham House Estate, I am at a loss to understand how the latter can largely increase the supply from the district. The distance between the proposed site and Green Lane is only 590 yards, and the end of the tunnel 1,300 yards, while that between the Windsor and Edge Hill wells is 960 yards; and in their case we find that the aggregate quantity of water raised is not much increased by adding to the wells, as before making the bore-hole at Windsor the railway wells at Edge Hill only gave a daily increase from that district of about 380,000 gallons. The proposed extension of the works towards Newsham House is little more than a repetition of these circumstances; the extent of tunnel is certainly greater, and will, in proportion, extend the contributing area, but not so efficiently as to justify the expectation of a very much more advantageous result, or one commensurate with the cost of the works.

The enquiry as to what distance wells should be placed from each other, in order to yield a maximum result, is here suggested. It is in evidence, that when the pumping at Green Lane was forced, wells not far from Windsor were affected, and others at a greater distance laid dry. These, perhaps, may be regarded as extreme cases; but I cannot think that two public wells, from which large quantities of water have to be drawn, should be established nearer to each other than Windsor and Green Lane, a distance of 1¾ or 2 miles. At this distance these wells appear to be capable of yielding 1,000,000 gallons a-day each.

The proposed tunnels at Windsor would operate as a reservoir, in which respect they would, no doubt, be useful for storage, but that they would sensibly increase the permanent yield of the well is very doubtful. The proposed additions to Bootle, the only station which supplies nearly 1,000,000 gallons per diem at about forty feet above low-water mark, will increase, for a time, the yield of that establishment; but in considering the question of its improvement, it must be remembered that it it is the most expensive on account of the royalty agreed to be paid annually to Lord Derby.

As I believe the results contemplated from this project to be but problematical, I cannot refrain from recommending a pause before entering upon the expenditure which the execution of the proposed works will necessarily involve.

Messrs. Simpson and Newlands' project, as described in their printed report of 23rd April, 1849, appears to be an extension of the Newsham House Scheme, involving a larger expense without, I fear, accomplishing a corresponding benefit.

The present Green Lane Works cost about 19,000*l.* for buildings, machinery, and wells, but exclusive of mains. The extension now proposed by driving a tunnel three miles long from the existing well (after it has been deepened), to the north, towards Melling, cannot, I believe, sufficiently increase the contributing area so as to add to the present yield 6,000,000 gallons a-day, as assumed by its projectors. No plans or details having been submitted to me, the only information I possess is that to be derived from the printed document and the general estimate, which do not enable a minute examination of the various items of cost to be made; but I do not doubt that the amount named, 192,556*l.*, is sufficient for the execution of the works.

Mr. Simpson, in the Kirkby or Clock House Bridge Scheme, proposes to obtain from wells situated near each other, and tunnels uniting them, 4,000,000 gallons a-day, and an equal quantity from two branches of the river Alt. The area of water-shed of this district would yield the quantity; but the proposed reservoir of about 30 acres in extent, and 15 feet in depth, would be quite inadequate as respects storage, to ensure so large an uniform daily supply; and I am satisfied, from a personal examination, that it would be a task of great difficulty to construct one sufficient for the purpose in this place.

The wells in this situation may probably be as productive as those elsewhere, although Mr. Binney and Mr. Rowlandson expressed some doubt of it, and the district is low, and the rock probably fully charged with water; but I can perceive no circumstance to justify us in supposing that the transmission of the water to this point can take place more easily than it has been found to do elsewhere, or data upon which to calculate safely on so large a supply as that suggested from wells situated at one point.

The engine-power requisite for the purpose of pumping 8,000,000 gallons a-day to Liverpool, is considerably under-rated; but, were the proposed works in other respects adequate to the necessary supply, I believe the aggregate estimate would be sufficient.

These observations on the Kirkby project are equally applicable to any proposal for deriving a supply from the Childwall Valley; indeed, every objection to the former applies with even greater force to the latter district. There is about the same area of water-shed, but greater difficulties as regards storage—to such a degree, that this alone is enough to put it entirely out of the question.

The proposed plans of the Marquis of Salisbury have also been examined; they consist of about three miles of tunnel, with their shafts, all comprised within an area of about three-quarters of a square mile, which is quite insufficient for the supply of the town; and even if considered merely as an auxiliary, the gain from it will be unequal to its probable cost.

(To be continued.)

OBITUARY.

SIR—I regret exceedingly to have to inform you of the death of a remarkably rising young architect, an occasional contributor to your *Journal*, Mr. John Swindell, of Kilburn Priory. His treatise on "Well Sinking," and other similar occasional minor performances, have at times been the subject of your favourable review. I have, however, well-founded reason to believe, that those small productions I have alluded to were merely the results of leisure hours; and that, had he not, by incessant work, worn out his frame, he would have ultimately benefited his profession in an eminent degree, by investigations of a far more important and more original character than those I have alluded to. I shall, I hope, find myself excused in your eyes, and those of your readers, in thus assisting to rescue from oblivion the name of one who, had he not come to an untimely grave, would have required no assistance of the sort.

I am, &c.
B. PEMBERTON,
Professor of Civil Engineering, R.A.C.

Royal Agricultural College,
June 11, 1850.

M. Luigi Zandomeneghi.—The *Venice Gazette* lately announced the death of this celebrated sculptor, aged 71. He had been for some years engaged in the sculpture of a magnificent monument to the memory of Titian. This important work, though far advanced, has been left unfinished by his death.

MOTLEY'S PROPOSED BRIDGE OVER THE AVON.

THE above engraving exhibits a design for a bridge of 600 feet span, which Mr. Motley proposes to construct over the river Avon, at St. Vincent's Rocks, Clifton: he states that it can be built without any centring. At a distance of 80 to 100 feet from the verge of the rock he proposes to drive a number of iron piles, united sufficiently strong to bear a strain of several thousand tons, to which powerful tension-bars would be fastened, on the river end of which cranes of sufficient strength would be attached, and, by the aid of a moveable platform, the first portion of the bridge would be hung on the principle of a suspended bracket; this would continue to be enlarged in length and depth, and as the work would commence on both sides simultaneously, the bridge would meet in the centre, and its perfect rigidity be effected. The cost of the iron work of such a bridge, Mr. Motley states, for a span of 600 feet, and to sustain a uniform load of 1000 tons, *with perfect safety*, would not exceed 30,000*l*. A model of the bridge may be seen at the office of the *Mining Journal*, in Fleet-street.

LAIRD'S GALVANISED IRON SECTIONAL BOATS.

Mr. Macgregor Laird has communicated to the *Nautical Magazine* the annexed illustration of iron-built galleys and boats he is now constructing. Mr. Laird states that this construction is a simple contrivance to enable merchant vessels to carry without inconvenience, boats that, in case of need, would save the lives of crew and passengers;—men-of-war, to carry double the number of boats in the space now occupied, discovery vessels to carry large tenders;—travellers to carry boats in the space of a moderately sized trunk;—and merchants trading to the open ports of the Pacific and Indian Oceans to send out lighters and small craft, at the usual rate of freight.

The sketches are the plans, elevations, and sections of two descriptions of boat, built on the sectional principle. The larger one (figs. 1 to 4) is a galley, 70 feet long and 12 feet beam, to be propelled by negroes with paddles.[*] This boat is for the use of her Majesty's Consul at Fernando Po, to enable him, without reference to calms or baffling winds, to proceed when required to any point within his district, which embraces the Bights of Benin, Biafra and Panasia, a line of coast of 1000 miles in extent, having the beautiful island of Fernando Po in the centre.

"To those of your readers who know Mr. Beecroft, and have been upon the coast, I need not remark upon the advantages, the facility of taking the boat to pieces, and reuniting her in a few hours without the assistance of mechanical or skilled labour, will give that distinguished traveller in his future geographical discoveries. And from my own experience I can truly say that if I had again to ascend any African river, I would prefer three or four of these galleys, each manned and propelled by fifty Kroomen, to the best equipped steamers that ever left England.

Commercially, steamers can only pay in civilised countries. Their excessive cost at first, and the constant outlay afterwards, has ruined all African trading expeditions into the interior; while

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[*] The following letter is from Commander Bevis, R.N., to Mr. Laird:—

"SIR—With reference to your letter of the 8th ult., with its enclosure from Mr. Macgregor Laird, relative to a sectional boat built of galvanised iron, said to be ready for survey on the 16th ult. (but is not yet in a finished state), and desiring me to take to my assistance some competent officer at Liverpool, who has been on the coast of Africa to inspect this boat, and report upon her efficiency, I beg to report for the information of my Lords Commissioners of the Admiralty, that I have on several occasions inspected the boat, and once in the presence of Mr. Beecroft, the Consul at Fernando Po, there being no African officer in this neighbourhood, and find her dimensions and efficiency as follows, viz.:—

Length	68 feet	Builder's Measurement ..	45 tons
Beam	12 "	Total weight of ironwork ..	4½ "
Depth amidships	4 "	Do. with woodwork, masts, sails, all complete	8 "
Depth forward and aft ..	6 "		

Thickness of plates 3-16 and ¼-inch; displacement at 1 foot water line 7·65 tons; ditto 2 feet 20 89 tons.

"There are eight sectional pieces, the heaviest of which is 16 cwt., joined together by angle-iron joints, lined with vulcanised indian rubber, the whole being secured together by screw-bolts and nuts, so that her own crew of forty or fifty men, can carry her over any neck of land, and set her up again.

"Her light draft of water is estimated at 1 foot with her crew, with provisions, water, &c., for the same, at 2 feet. She is to pull thirty-eight oars, double-banked, fitted with three schooner sails, jib and square-sail, having for night protection iron stanchions covered with thin felt; she is also to be fitted with air-tight galvanised tubes as a life-boat.

"From her light draft of water, and general lightness, she is particularly well adapted to take the bars on the coast of Africa, where there is a short breaking sea, and *for proceeding up the rivers, or to go in chase of slavers, as from her construction she must pull and sail very fast*.

"It is proposed by Mr. Beecroft, that this boat should be fitted with a light brass six-pounder forwards; and with her crew trained to small arms, she would be fit to go in chase of any slavers in a calm, therefore submit that this class of boat, with increased or diminished dimensions, would be of great service to the African squadron as tenders.

"I am, &c.,

Liverpool, 7th March, 1850. "THOMAS BEVIS, Commander."

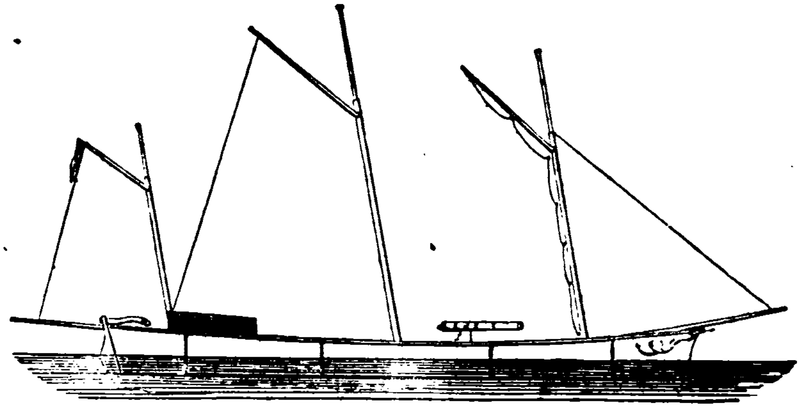
galleys of this description would have done all that has been done at a twentieth of the cost, and perhaps 'ere this, have opened a regular and steady trade with the tribes in the interior.

The second boat is building for an emigrant ship (figs. 5 to 8). She is in four sections, and can be used as an ordinary boat of 26 feet long (figs. 7 and 10), as a barge 38 feet, or a galley of 50 feet (fig. 5), at which size she would carry in safety 150 people.

Fire is the great danger to be apprehended on board emigrant vessels. In an hour after a fire was discovered these boats could be joined and towing astern, and the awful scenes that took place on board the *Ocean Monarch* and *Caleb Grimshaw* avoided.

All naval officers who have served on the coast of Africa, and the Indian Seas, know the advantages of having large and fast boats. On this sectional plan, a boat 60 feet long can be stowed in a length of 25 feet on the booms, and be put together in a few minutes by her crew, when her services are required to chase in calms or baffling winds, or to land troops; or, fitted as a tender, she could be sent to cruise with a month's provisions and water on board; a simple and cheap way of doubling the efficiency of a blockading squadron. Droghers, lighters, and small craft of all sorts and sizes, can be sent out to all parts of the world, at the lowest rate of freight, and put together with the greatest facility and accuracy, without the aid of mechanics or skilled labourers.

I may add, that I propose making all boats for passenger-vessels life-boats, by using Light's prepared rushes, which are much superior to any system of air-chambers, and securing them from oxidation by galvanising the plates, which also saves the expense of painting."



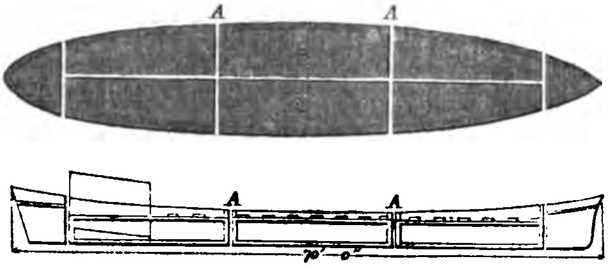
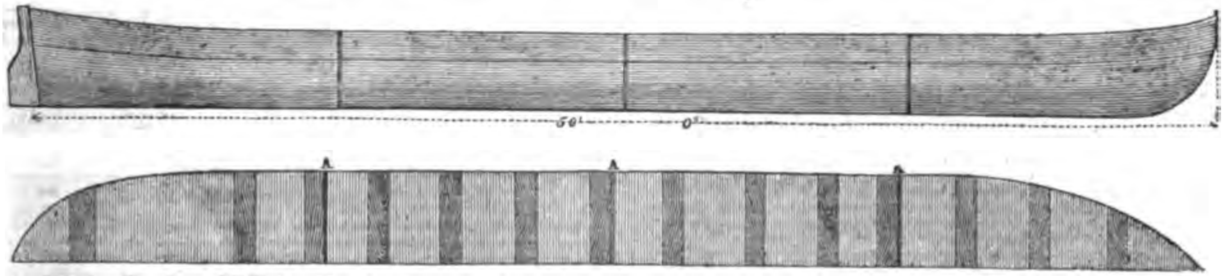


Fig. 4.—Cross Section at A.

Figs. 1, 2, and 3. -Elevation, Plan and Section of a Galley, 70 feet long.



Figs. 5 and 6.—Elevation and Half-plan of Sectional Boats of Galvanized Iron, for an Emigrant Ship of 600 tons, carrying 300 people. Scale ⅛ of an inch to a foot.

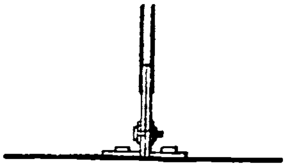


Fig. 7.—Plan of Section at A.

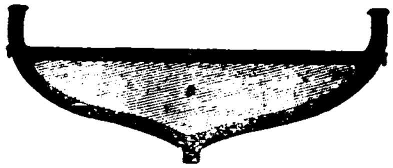


Fig. 8.—Cross Section at A, showing the method of joining the Sections. Scale ½ of an inch to a foot.

Fig. 11.—B, Water-tight Bulkheads, Sections at end of Midship Sections, showing the Sections as a Deck-house.

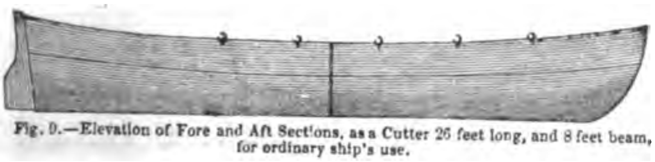


Fig. 9.—Elevation of Fore and Aft Sections, as a Cutter 26 feet long, and 8 feet beam, for ordinary ship's use.

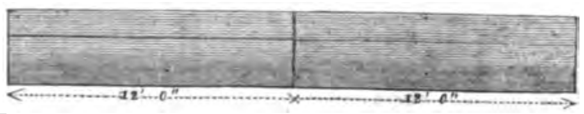


Fig. 10.—Midship Sections, stowed on Booms, to be used as store-rooms, or water-tanks, on the voyage, containing upwards of 3000 gallons.

SUPPLY OF WATER TO THE METROPOLIS.

REPORT *by the General Board of Health on the Supply of Water to the Metropolis.*

WE have given at length the recommendations of the Commissioners, as to the plan they propose for adoption; but the report itself requires considerable discussion, which we must, however, defer, our space being otherwise taken up.

Quality of the Water of the River Thames.

1. That for domestic use it is inferior to the average quality of waters supplied to towns.

2. That its inferiority as a supply for domestic use arises chiefly from an excess of hardness.

3. That even when taken above the reach of pollution from the sewers of the metropolis it contains an excess, varying with the season, of animal and vegetable matter.

4. That although this latter cause of inferiority may be in part removed or corrected by filtration, the excess of hardness will still remain, rendering this water especially unfit for the following uses—namely, for cleansing the skin and for ordinary purposes of washing, by occasioning an excessive consumption of soap; for the preparation of tea, by occasioning waste to the like extent; and for all culinary processes by diminishing their efficiency and increasing their expense.

5. That the quality of the water in the river Lea and of the New River is, in this respect, no better than that of the Thames water taken beyond the influence of the sewage of the metropolis.

6. That the water taken by the Lambeth Company from the Thames opposite Hungerford-market is charged with animal and vegetable impurities, apparently the effect of the discharge of sewer water, which render it wholly unfit for use, and highly dangerous to the health of the persons who drink it.

7. That of the seven principal companies by which pipe water is conveyed to the metropolis, four deliver it without previous filtration.

8. That the defects in the quality of the water at present supplied, when collected in its least objectionable condition, and the evils arising from its distribution in the unfiltered state, are all aggravated by the practice of intermittent distribution.

9. That the practice of intermittent distribution occasions, in the case of the better description of houses, the retention of the water in cisterns and butts, and in that of the poorest classes, in tubs, pitchers, and such other vessels as can be obtained; and, as a consequence of such retention, the water imbibes soot and dirt, and absorbs the polluted air of the town, and of the offensively close, crowded, and unhealthy localities and rooms in which the poor reside.

10. That from the inferiority of the water at its source as at present collected, and from the additional pollution and deterioration occasioned by the mode of its distribution, a large proportion of the population is rendered averse to the daily use of water as a beverage, and is inclined and almost forced to the use of fermented liquors and ardent spirits to an extent greatly beyond the consumption of such drinks where purer water is more accessible.

11. That the annual cost of the construction and maintenance in repair of cisterns and their supports and connected apparatus in the houses of the middle and wealthier classes often exceeds the annual water-rate.

12. The cost of the pipe water supply and the additional expense and inconvenience resulting from the present mode of its distribution cause the population in some suburban districts to resort for water to open ditches, and in other crowded localities to shallow springs or wells; sources which are subject to increasing pollution from cesspools, from badly constructed house drains and sewers, and from overcrowded graveyards.

13. That the localisation and intensity of cholera in such districts as those alluded to were promoted in a most marked manner by the use of water containing decomposing animal and vegetable matter derived from sewers, drains, and other impure sources.

14. That the districts most severely visited by epidemic cholera, as well as those afflicted by ordinary epidemic diseases, are low-lying districts where, from the defective state of the drainage, there is an excess of damp and of putrid decomposition; and that such excess of damp is aggravated by the waste of water attendant on the intermittent mode of supply; a waste which appears to exceed the whole of the annual rainfall on the inhabited area of the metropolis.

Constant Supply System.

Many practical difficulties having been urged against the substitution of the constant for the intermittent system of water supply in the metropolis, we have particularly examined into the working of the constant system of towns where it is established, and in some of which it has been in operation for 15 and 20 years, and we find—

15. That the waste of water is so far less, instead of greater, under the system of constant supply, that although the inhabitants have unlimited command of water, and use what they please, though the actual use of water by the inhabitants is greater, the quantity delivered by the companies is less, frequently less by one-half; in consequence of there being less waste from the more perfect delivery.

16. That the water, under the system of constant supply, is delivered purer and fresher, of a lower temperature in summer, and that it is less subject to frost in winter.

17. That the inconvenience apprehended from the interruption of supply during repairs and alterations, are never experienced, the work being executed under such simple precautions that no complaint has ever been known to have been made on this account.

18. That the interruptions of supply, which are so constantly experienced on the intermittent system from the waste in the lower districts, from the neglect of turncocks, from limitation of quantity, from inadequate or leaky butts and cisterns, or from deranged ballcocks, are scarcely ever known on the constant system.

19. That the system of constant supply admits of great economy in pipes, as they may, under that system, for the most part, be considerably smaller, and, not being subject to the violent hydraulic jerks of the intermittent system, are less liable to burst.

20. That the pipes for the house service may not only be considerably smaller and cheaper, but that the cisterns and apparatus connected therewith, which, in the smaller class of houses, now cost more then the whole public portion of the works, may be entirely dispensed with.

Quantity requisite.

In respect to the quantity of water actually supplied, and to the quantity needed for the domestic use of the metropolitan population, and for other purposes, we have to report—

That in consequence of statements made by several of the companies of the quantities of water which they pumped for the use of the metropolis, quantities which appeared to be inconsistent with the known habits of the population and the apparent amount of water consumed for domestic purposes, we deemed it desirable to cause the consumption of water in different districts, by different classes of the population, to be gauged from the cisterns and butts, and also the run through house-drains and sewers on days when there was no rainfall.

From these observations it appears—

21. That, whereas it was returned, in 1832, that the average quantity of water delivered to their respective customers by the several companies was 220 gallons per house or dwelling—and more recently, as returned to us, was stated to be 164 gallons per house or dwelling—that is, 44,000,000 gallons per diem for the whole of the metropolis—making allowances for a considerable and injurious waste of water by permeation through badly constructed channels, the results of the gaugings of the run of water through drains and sewers, on days when there is no rainfall, do not appear materially to differ from the later statements of the several companies as to the quantity of water which is actually pumped into their several districts; while from the gaugings of the quantities of water consumed from cisterns and butts during the intervals of the intermittent delivery, and from the capacity of the storage receptacles themselves, it appears that the average daily consumption does not exceed five gallons per head on the population, and that, with all allowances for the quantities used for manufactures, steam-engines, and other purposes, the gross quantity consumed does not exceed one-half of the quantity delivered.

22. That this waste is a consequence of the present intermittent mode of supply, and does not take place to any such extent where the constant system of supply has been substituted, and probably may be prevented altogether where the house service pipes are properly provided and arranged under a system of combined works.

23. That this waste, as now ascertained by official investigation, appears to have gone on without any knowledge of its great amount on the part of the companies, although it involves a double expense of pumping, and exceeds, as above-stated, the whole of the annual rainfall on the covered area of the metropolis.

24. That this waste is of no equivalent benefit for the cleansing of house drains and sewers, inasmuch as, from the inaptitude of these works, owing to their bad construction, for the discharge of water containing matter in suspension, accumulations of decomposing matters do take place in them to the great injury of the public health; accumulations which, notwithstanding the flow of the waste water through them, require to be cleared away by hand labour, flushing, or by other means.

25. That the waste water, having sewer matter mixed up with it, permeates through the brick drains and sewers, saturates the sites of houses with polluted water, and keeps up an excess of moisture which, rising into the porous and absorbent walls and plaster of the houses, contributes to render them damp even in the driest weather.

26. That this excess of moisture is aggravated by the extremely defective drainage in the low-lying and worst-conditioned districts, where, as has been already stated, epidemic disease is almost invariably present, and where the recent visitation of epidemic cholera has been the most severe.

27. That, taking into consideration the actual domestic consumption of water by the population of the metropolis, regarding also the extent of the increased supplies needed for the various purposes of sanitary improvement not hitherto contemplated by companies, nor included in new schemes, all the engineering estimates put forward by private companies of the quantity of water required for the service of the population, appear to be greatly in excess.

28. That there appears to be no probable demand for a general average consumption of water exceeding the present rate for houses of the higher class—namely, about 75 gallons per house per diem; or, in all, 22,000,000 of gallons per diem, inclusive of the increased supply which will be necessary on the abolition of cesspools; and that, estimating the additional requirements for baths, for street-cleansing, for large consumers, for fires, and for other purposes, the whole quantity of water needed under an improved system of distribution does not exceed 40,000,000 of gallons per diem.

29. That it appears that the resolutions of parochial meetings and the statements of the promoters of new companies, alleging a deficiency in the total amount of water already introduced, and proposing to bring in additional supplies, have been made in ignorance of the actual present domestic consumption of the population, and of what is really needed, according to the best information, for the execution of practical measures of sanitary improvement.

30. That the several schemes which propose to bring in more water in addition to the quantity now wasted, and to make such additions mainly from the same sources which supply the water now generally consumed, without reference to improvements in the system of domestic distribution, and without combination with improved drainage-works for the removal of the waste water, would aggravate the existing sanitary evils, and increase the excessive charges already incurred for the defective works constructed in ignorance.

Flushing System.

Having particularly examined the statements as to the increased quantities of water required for the flushing of drains and sewers, and the working of an improved system of drainage, we find—

31. That upon a system of drainage such as that at present in use, consisting of brick house-drains and sewers, which cause accumulations of decomposing deposits, there would be required, for the intermittent removal of those accumulations by flushing, considerable additions to the present quantities of pipe water pumped in for the supply of the metropolis, but that any system of house or main drainage which occasions the accumulation of decomposing refuse, and renders necessary the continuance of the practice of intermittent flushing, is in itself highly injurious to the public health, and ought to be prevented.

32. That recent trial works have placed beyond doubt the soundness of the conclusion of the Metropolitan Sanitary Commissioners—namely, that systematically adjusted tubular house drains and sewers are kept clear of deposit by the force of the soil or sewer water alone, when conducted away at proper levels; and that no addition of water is required for this purpose.

Sewerage of the Metropolis.

With reference to those extensive districts of the metropolis the levels of which are below high-water mark, where the sewer water is at present penned up until it can be discharged at low water, and where putrefying deposit is accumulated in the sewers in consequence of the flow being arrested during high water, it appears—

33. That it will require no addition of water, and certainly no increased expense in pumping, to cause such a continuous flow of the waste water as will prevent deposit; and that this prevention of deposit is the true object to be aimed at, and not the supply of additional quantities of water to remove, by flushing, deposit which ought not to have been allowed to accumulate.

34. That besides the great injury to the public health from the ponding up of sewer water and the consequent conversion of large expansive sewers and reservoirs into extended cesspools; and, besides the waste of water and the expense of pumping it into the district for the removal of accumulations, the intermittent system of draining the districts below high-water mark by gravitation, without the aid of pumping for their relief, must necessitate the continued pollution of the Thames, and obstruct or delay the application of the refuse as manure.

35. That, except in extreme cases of absolute deficiency, the pumping in of additional supplies of water, before properly constructed house drains are laid down for its removal, would, by increasing damp, still further deteriorate the sanitary condition of the population, and occasion still greater dilapidations and injury to tenements.

36. That the separation of works of pipewater supply from those for the removal of waste water occasions delay in the execution of works of primary importance for sanitary improvements, as well as increased expense.

37. That it appears that while the expense of sewers and drains is reduced by an improved tubular system of drainage, the expense of earth-work, of digging, and making good, is one half of the total expense, and that, therefore, the separate laying down of watermains and drainage mains must frequently cause this last portion of the expense to be materially increased.

38. That on these grounds, and on the principles already recognised, the only way of securing systematic works with economy and efficiency, as well as with the least delay,

will be to consolidate under one and the same public management, the whole works for the supply of water, and for the drainage of the metropolis.

39. That it is essential to the economy and efficiency of all such works that the whole distributory apparatus, small as well as large, service pipes, and house drains, together with watermains, public drains, and sewers, should be laid down under one system, and kept in action under one supervision.

40. That it appears from the examination of improved works which have been in operation for a sufficient length of time to test their efficiency, and from detailed estimates made by different competent engineering officers upon house-to-house examinations of the worse conditioned districts, that combined works, comprising a water pipe for the service of each house, a sink, a drain, a waste pipe, and a soil-pan or watercloset apparatus, may be laid down and maintained in action at a cost not exceeding, on the average, 1½d. per week, or less than half the average expense of cleansing the cesspool for any single tenement.

41. That the general survey being now sufficiently advanced, such works may be executed for separate districts, without waiting for the completion of any general measure or plan of main sewers.

Provision for Supply.

Having considered the evidence in relation to the qualities of the water requisite for the supply of the metropolis, we find:—

42. That, in addition to the properties of clearness and freedom from animal and vegetable matter which is apt to pass into decomposition and to prove injurious to health, one of the most essential properties of water is softness, or freedom from lime and other substances productive of what is termed hardness.

43. That, having made careful and extensive inquiries, with the aid of the department of the Ordnance geological survey, as to the most suitable sources of supply, having had those districts which appeared to be the most eligible specially examined by our engineering inspectors, with other aid, we find, upon their unanimous testimony, that from a tract of upwards of 150 square miles of gathering ground[*] there is derivable a supply nearly double the present actual domestic consumption, of a quality varying from one-tenth to one-third the hardness of Thames water, and of a purity equalling the general average of the improved soft-water supplies of the districts which have yet been brought under examination.

44. That water obtained from silicious sands, such as those which cover the tract above described, is proved to be of a quality only equalled in excellence by the water derived from mountain granite rocks, or slate rocks, or other surfaces of the primitive formations.

45. That upon the estimates which have been obtained, this water may be brought to the metropolis and delivered pure and filtered into each house on the system of constant supply at high pressure, and, at the same time, on the plan of combined works, the waste water may be removed by a proper system of drainage, at a rate not exceeding an average of 3*d* or 4*d* per week per house, or from 30 to 50 per cent. less than the present charges for defective water supply alone.

46. That the saving of soap, from the use of soft water in the operation of washing (the expense of washing linen and other clothes being estimated at an average of 1*s*. per head per week to be nearly 5,000,000*l*. per annum on the population of the metropolis) would be probably equivalent to the whole of the money expended at present in the water supply.

47. That the saving in tea from the use of soft water may be estimated at about one-third of the tea consumed in the metropolis.

48. That other culinary operations would be much facilitated by the use of soft water.

49. That soft water is peculiarly suitable for baths, as well as for washing.

50. That soft water would prevent those incrustations and deposits in boilers and pipes which render hard water unsuitable for manufacturing purposes.

Recommendations of the Commission.

We therefore advise the rejection of all the schemes promoted by water companies, or by parochial vestries and associations, which adopt, as sources of supply, the Thames and its tributaries of the same degree of hardness, wells, and springs from the chalk or other formations which impart the quality of hardness.

And further, whilst we believe that Thames water taken up beyond the influence of the metropolitan drainage, and filtered, may be used without injury to the public health, and may be employed temporarily until other sources can be laid under contribution, we advise that Thames water, and other water of like quality as to hardness, be as early as practicable abandoned.

In respect to the existing companies which have no property in any of the sources of water supply, but whose capital is invested in engines and distributory apparatus, we recommend that their plants should be purchased, but we are not prepared to recommend any pre-appointed terms of purchase; and we find—

51. That, if the management of the water supply be consolidated, five if not six out of the seven principal pumping establishments may be discontinued, and an expenditure of from 80,000*l*. to 100,000*l*. per annum saved by consolidating the management of these works and connecting them with combined works of drainage and sewerage, and that further reductions may be made in the expenses of these latter establishments.

Having considered, as required under the Metropolitan Sanitary Commission, the means of supplying water to extinguish fires, and having examined the practical experience of improved works in relations thereto in other towns, we find—

52. That the inadequacy of the supplies of water under the intermittent system occasions great danger to life and property, but that by arrangements which are practicable under a system of constant supply at high pressure, the whole force of the water in the mains may be brought to bear at any point for extinguishing fire in from one to five minutes, or in about one-fourth the time that it takes the best appointed fire-engines now to gain the spot and be in action after the alarm of fire has been given.

53. That, judging from the experience of various places where improved arrangements have been put in practice, it appears that by the general adoption of these arrangements more than two-thirds of the fires which now occur in the metropolis may be extinguished before any extensive damage takes place.

54. That the insurance risks on life and property may be diminished in a yet greater proportion.

55. That the crime of incendiarism may be checked, and that these consequences alone, were there no other advantages to be obtained, would render it worth while to make the change from the intermittent to the constant system.

56. That these advantages may be best given by the same means by which a more perfect and cheaper surface cleansing of courts, alleys, foot-pavements, and carriage-ways than that by hand may be effected—namely, by jets of water distributed under high pressure.

Proposed Plan for the Metropolis.

Having considered the most eligible administrative provisions for the execution of the required works, we concur in the principles recommended by the commission of inquiry as to the best means of improving the health of towns, and confirmed by Parliament in the Public Health Act, viz.:—

57. That the works of water supply, and those for drainage, or the removal of soil or waste water, should be carried into effect by one and the same administrative body.

58. But that the magnitude of the metropolis, the diversity of its local jurisdictions, and its position as the seat of government, and the occasional residence of persons from all parts of the empire, the large minorities requiring protection, and the unaccustomed magnitude of the requisite outlay, render distinct and special provisions necessary for it, and that the amendments required may be most speedily, safely, and economically executed by special or by provisional arrangements.

59. That a general survey under the direction of the engineers of the Board of Ordnance, and other surveys, trial works, and preparations essential to the safe and economical executions of combined works of water supply having been completed, under the direction of the consolidated Metropolitan Sewers Commission, such combined works may now be executed and maintained at a lower rate of charge per house than has heretofore been incurred for any of their various branches executed separately.

60. That the initiation and executive direction of such works by members, however highly qualified, giving casual attendance at meetings held weekly or fortnightly, causes grievous delay, and that in cases which measures for preventing disease or arresting its progress require the utmost promptitude.

61. That, considering the great loss and suffering incurred by the delay in carrying the required works into execution, it will be expedient to confide their further preparation and superintendence to a few competent and responsible officers, of whom a certain portion should be paid, giving their whole time and attention to the subject. That the whole of these works be carried into execution by contract upon open tenders, not merely for the construction of the works, but for maintaining them in good action and repair for terms of years.

62. That the means provided by the Public Health Act for giving publicity to plans and estimates of intended works, with opportunities of suggestion and appeal, be extended to the works proposed for the sanitary improvement of the metropolis.

63. That the proper execution of the works will be best guaranteed, the responsibility of the persons charged with their execution best insured, and the interest of the poorest classes of the population (the inhabitants of the most depressed districts, who, though they pay no direct local rates, pay heavy rents), will be best guarded in the special case of the metropolis, at all events provisionally, by the direct control of Parliament; the importance of the proposed measures to the health, convenience, and comfort of large masses of the population, the magnitude of the required constructions, the amount of outlay, and the dangers of failure and waste as well as delay being, from experience of separate works already constructed, such as to render it necessary that the highest order of continued and undivided attention and responsibility should be secured for the execution of such works as this Report recommends.

ROYAL SCOTTISH SOCIETY OF ARTS.

April 22.—PATRICK WILSON, Esq., in the Chair.

The following communications were made:—

1. *On a New Method of inducing an upward Current in the Upcast Shaft of Coal-Mines, to promote Ventilation.* By Mr. J. SETON RITCHIE, Edinburgh.—The author adverted to the vast numbers, as workers, and dependants on them, interested in the adoption of means by which freedom from danger in coal-mines may be attained; then, mentioning the theories by which mine-explosions are accounted for, he noticed the numerous methods which have been proposed for maintaining mines in a state of safety, and particularly the method in general use of inducing an upward current of the air of the mine by means of a fire at the lower part of the upcast shaft, that, as the provision of a separate shaft for the removal of the air of the mine is prevented by the great additional expense, even though mechanical appliances may appear highly calculated to maintain a powerful and steady current, difficulty exists in their application, as interfering with the free working of the produce of the mine carried on by the upcast shaft, which is further increased in making provision for continual reliance on them, as spare appliances would require to be provided. The author stated that the method now proposed is free from this obstacle. The current is induced by means of pipes heated by water circulating in them, fixed round the circumference of the shaft in such manner within the line of it, as shall shield them from injury, leaving sufficient exposure of them to communicate their heat to the air in the shaft; the furnaces for heating the circulating water being at the nearest convenient distance, at a considerably lower level than the orifice of the shaft, as on the depth at which they are placed will depend the perpendicular extent of the upper part of the shaft around which the pipes may be placed. Certainty of action could, with ordinary caution, be relied on, as, even if one of the circulations ceased, from any cause, to act, the others would during that time continue in action. A similar application might also be made at the lower orifice of the shaft, and even extended in some measure to the workings; or the fires now in use at the foot of the shaft might be retained, and the application alone made at the upper part in aid, to promote greater certainty and steadiness in the current. It was submitted that a similar application might be made of steam as of water. It was pointed out that the maintaining of the upward current in the shaft is but one section of the keeping the mine in a state of safety—that, though this will never be effected without a steady and powerful extracting current in the shaft, the latter will be of little avail, unless accompanied by carefully-laid-out air-courses throughout the mine itself, properly modified as the working advances, attention on the part of those appointed to open and close the doors which it becomes necessary to erect in them to direct the currents, and attention that that the building off of exhausted sections of the mine be as frequently as possible accomplished, that they may not become next to permanent reservoirs of noxious gases, ready to lend their aid to a general explosion.

2. *Description of a Water-Meter.* By Mr. F. A. BUCKNALL, New Swindon, Wilts.—The author stated that the object of this meter is the measurement of the supply of water to private dwellings, breweries, &c. It consists chiefly of a fan-shaped bucket-wheel, revolving within a cylindrical case, and kept water-tight by means of packing, made of India-rubber, leather, or other elastic substance, supply and delivery pipes, and wheel and pinion gear, which is connected with an index plate. The revolving action of the meter is maintained by the gravity of the wheel being constantly greater on the one side than on the other, owing to the continuous running off of the

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[*] The district from which the proposed supply is to be taken is Bagshot Heath.

water from the opposite side to that at which the water is supplied. The meter is only in action during the time the water is running off.

3. *Description of a New Liquor-Pump, calculated to prevent the Liquor from being contaminated with Verdigris and Oil in the interior of the Pump-Barrel; also applicable to the Pumping of Acids.* By Mr. Hay Dall, Glasgow.—The author stated the following as the disadvantages of the present system of pumping liquors—1st, That each liquor requires a separate pump. 2nd, That the liquor, in passing through the barrel of the pump, corrodes its interior, especially in the case of fermented liquors, thus producing constant decay in the barrel and valves, and also an accumulation of verdigris in brass pump-barrels, which, together with the oil or tallow used to lubricate the piston, is constantly mixing with and contaminating the liquor. The inventor stated that he had his attention frequently directed to the disgusting state of the interior of corroded pump-barrels which had been sent in for repair—that, generally, every crevice and corner of the piston and barrel where it could collect, was clogged with a poisonous and nauseous compound of stale beer and oily verdigris, ready to mix in greater or less quantity with the next liquor that would pass through it. That in the new method one pump can be made to supply any number of liquors, while the liquor never gets into contact with the pump-barrel. The pump is used solely as an air-pump to withdraw the air from the interior of a series of glass or earthenware vessels, properly arranged, and made to communicate with the liquor casks by tubes immersed in the liquor. When the cocks are properly arranged, and the pump is worked, the liquor rises and fills the vessel, never having passed through the pump barrel at all, and when the vessel is full, the pumping is stopt, and the liquor is run off into the vessels from which it is to be drunk, by a common cock.

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM MAY 23, TO JUNE 20, 1850.

Six Months allowed for Enrolment, unless otherwise expressed.

William Radley, chemical engineer, and Frederick Meyer, oil merchant, both of Lambeth, Surrey, for improvements in treating fatty oleaginous resinous, bituminous, and cerous bodies, in the manufacture and application of them, and of their components and subsidiary products, together with the apparatus to be employed therein to new and other useful purposes.—May 25.

Edwin Pettitt, of Birmingham, civil engineer, for improvements in the manufacture of glass, in the method of forming or shaping and ornamenting vessels and articles of glass, and in the construction of furnaces and annealing kilns.—May 25,

John Hickman, of Walsall, Stafford, clerk, for improvements in the manufacture of cylindrical and other tubes.—May 25.

Alfred Vincent Newton, of Chancery-lane, mechanical draughtsman, for improvements in couplings for carriages, and in the attachment of wheels to axles. (A communication.)—May 28.

James Ashworth, of Rochdale, Lancaster, manufacturer, and Thomas Mitchell, of the same place, manager, for certain improvements in machinery or apparatus for preparing, spinning, and weaving cotton, wool, and other fibrous materials.—May 29.

Jonathan Harlow, of Birmingham, for improvements in the manufacture of bedsteads and other articles for sitting or reclining on.—May 30.

Edwyn John Jeffery Dixon, of the Royal Slate Quarries, Bryntrafood, near Bangor, North Wales, for improvements in the manufacture of sinks and other articles of slate or stone.—May 30.

Thomas Page, of Middle Scotland-yard, Middlesex, civil engineer, for improvements in the construction and means of cleansing sewers.—June 1.

Ezra Jenks Coates, of Bread-street, Cheapside, London, merchant, for improvements in the manufacture of bolts, spikes, and nails.—June 1.

Moses Poole, of the Patent Bill Office, London, gentleman, for improvements in machinery for punching metals, and in the construction of springs for carriages and other uses.—June 1.

Arthur Elliott, machine maker, of Manchester, and Henry Heys, of the same place, book-keeper, for certain improvements in machinery for manufacturing woven fabrics.—June 1.

Guillaume Ferdinand de Douhet, of Clermont Ferrand, France, gentleman, for improvements in the disoxygenation of certain bodies, and the application, separately or simultaneously, of the products therefrom to various useful purposes.—June 1.

Frank Clarke Hills and George Hills, of Deptford, Kent, manufacturing chemists, for certain improvements in manufacturing and refining sugar.—June 1.

Samuel Brown, of Lambeth, Surrey, engineer, for improvements in engines for measuring and registering the flow of fluids and substances in a fluid state, which improvements are also applicable to steam and other motive engines —June 1.

John Tucker, of the Royal Dockyard, Woolwich, Kent, shipwright, for improvements in steam boilers, and in gearing, cleansing, and propelling vessels. (A communication.) —June 1.

George Hayward Ford, of St. Martin's-le-Grand, Middlesex, gentleman, for improvements in obtaining power.—June 3.

Paul d'Angely, of Paris, France, gentleman, for certain improvements in the construction of privies and urinals, and in apparatus and machinery for cleansing privies, cesspools, and other places, and in deodorising the matter extracted therefrom, and rendering it available for agricultural purposes.—June 4.

David Napier and James Murdock Napier, of the York-road, Lambeth, Surrey, engineers, for their invention of improvements in apparatus for separating fluid from other matters.—June 4.

Theodore Cartali, of Manchester, merchant, for certain improvements in the treatment or preparation of yarns, or threads, for weaving. (A communication.)—June 4.

William Watson, the younger, of Chapel Allerton, York, manufacturing chemist, for improvements in the preparation and manufacture of various materials to be used in the processes of dyeing, printing, and colouring.—June 4.

John Sykes and Adam Ogden, both of Dock street, Huddersfield, York, wool cleaners and machine makers, for certain improvements in machinery for cleaning wool, cotton, and similar fibrous substances from burrs, motes, and other extraneous matter.—June 4.

Edmund Sharpe, of Lancaster, master of arts, for certain improvements in railway carriages.—June 5.

William Edward Newton, of Chancery-lane, civil engineer, for improvements applicable to boots, shoes, and other coverings for, or appliances to the feet.—(A communication.)—July 6.

George Jackson, of Belfast, Ireland, flax-spinner, for improvements in heckling machinery.—June 6.

John McNicoll, of Liverpool, engineer, for improvements in machinery for raising and conveying weights.—June 6.

William Robertson, of Gateside-hill, Neilstone, Renfrew, Scotland, machine maker, for improvements in certain machinery used for spinning and doubling cotton, and other fibrous substances.—June 6.

James Alexander Hamilton Bell, New York, America, merchant, for improvements in dressing bran, pollard, and sharps. (A communication.)—June 6.

A grant unto William George Bicknell, of Essex-street, Strand, and James Reginald Torin Graham, of the Grove, Clapham Common, of an extension for the term of six years of letters patent granted by his late Majesty King William IV., to Miles Berry, of Chancery-lane, patent agent, for certain improvements in machinery or apparatus for cleaning, purifying, and drying, wheat or other grain or seeds.—June 7

William Newton, of Chancery-lane, civil engineer, for certain improvements in the manufacture of cords, ropes, bands, strong cloths, quilting, sacks, and cushions, and in elastic material for stuffing the latter, in which manufacture caoutchouc forms an essential ingredient, and in the application of parts of these improvements to the manufacture of pads, stoppers, tubes, boxes, baskets, coverings, wrappers, and other like articles of utility. (A communication).—June 8.

James Colman, of Stoke Mills, Stoke, near Norwich, Norfolk, mustard and starch manufacturer, for improvements in the manufacture of starch.—June 8.

Peter Armand Lecomte de Fontainemoreau, of South-street, Finsbury, London, for certain improvements in oscillating engines put in motion by steam and gas resulting from combustion. (A communication).—June 8.

Charles Warwick, of Cheapside, warehouseman, for improvements in apparatus for taking up the work of certain descriptions of knitting machinery. (A communication)—June 8.

Peter Armand Lecomte de Fontainemoreau, of South-street, Finsbury, for certain improvements in the manufacture of sulphate of soda, muriatic and nitric acids. (A communication).—June 11.

William Edward Newton, of Chancery-lane, civil engineer, for improvements in machinery for carding cotton, wool, or other fibrous materials, and an apparatus for preparing or setting the cards of carding engines. (A communication)—June 11.

William Jackson, of Kingston-upon-Hull, soap maker, for improvements in the manufacture of soap, and in the preparation of materials for this purpose.—June 11.

William Edward Newton, of Chancery-lane, civil engineer, for improvements in rotary engines. (A communication).—June 11.

Robert Waddell, of Liverpool, Lancaster, engineer, for certain improvements in steam engines. (A communication)—June 11.

Alexander Parkes, of Pembrey, Carmarthenshire, experimental chemist, for improvements in smelting and treating certain metals, and in the construction and manufacture of furnaces and the materials to be used for the same, such furnaces and materials being applicable to the treatment of metals and metallic compounds, and to various other useful purposes of a like nature.—June 11.

William Pole, of Great George-street, Westminster, engineer, and David Thomson, of Belgrave-road, Pimlico, engineer, for improvements in steam-engines.—June 11.

John Henry Vries, Esq., of Norfolk-street, Strand, Middlesex, for improvements in working engines by atmospheric air.—June 11.

James Palmer Budd, of the Ystalyfera Iron Works, Swansea, merchant, for improvements in the manufacture of coke.—June 11.

John Dearman Dunnicliff, of Hyson Green, Nottingham, lace manufacturer, and John Woodhouse Bagley, of Radford, in the said county, lace maker, for certain improvements in lace and other weaving.—June 11.

Samuel Ellis, of Salford, engineer, for improvements in machinery or apparatus applicable to all kinds of carriages used on railways.—June 11.

Frederick Albert Gatty, of Accrington, Lancaster, manufacturing chemist, for a certain process or certain processes for obtaining a carbonate of soda and carbonate of potash.—June 11.

William Cox, of the firm of William Cox and Co., of Manchester, cigar merchant, for certain improvements in machinery or apparatus for manufacturing aerated waters, or other such liquids.—June 11.

John Sidebottom, of Broadbottom, Chester, manufacturer, for improvements in looms for weaving.—June 11.

William Mac Lardy, of Manchester, machinist, for certain improvements in machinery or apparatus for preparing and finishing, and doubling cotton and other fibrous materials.—June 12.

Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for improvements in the production of gases to be used for lighting, heating, and motive power purposes. (A communication).—June 12.

Gustavus Palmer Harding, of Bartlett's-buildings, London, artificial florist, for improvements in the manufacture of buttons and other fastenings.—June 12.

Thomas Deakin, of Balsall Heath, Worcester, Esq., for certain improvements in machinery and apparatus to be used in rolling metals and in the manufacture of metal tubes —June 12.

John Stopporton, of the Isle of Man, engineer, for certain improvements in propelling vessels.—June 12.

William Edward Newton, of Chancery-lane, civil engineer, for certain improvements in the construction of railways. (A communication.)—June 12.

George Allen Everitt, of the firm of Allen, Everitt, and Son, of the Kingston Metal Works, Birmingham, metal and tube manufacturers, and George Glydon, of Birmingham aforesaid, engineer and foreman to the said Allen, Everitt, and Son, for certain improvements in the manufacture of metal tubes for locomotive, marine, and other boilers.—June 12.

John Manly, jun., of Birmingham, manufacturer, for certain improvements in the manufacture of nails.—June 12.

Charles Lamport, of Wortrington, Cumberland, ship-builder, for certain improvements in machinery or apparatus for lifting and moving weights, working chains, and pumping, which improvements are more especially adapted to ship use —June 19.

Charles Greenway, of Green-street, Grosvenor-square, Middlesex, for improvements in ships' and other pumps, in anchors, and in propelling vessels.—June 19.

Benjamin Cheverton, of Camden-street, Camden-town, Middlesex, artist, for methods of imitating ivory and bone.—June 19.

Charles Hanson, of Stepney, Middlesex, engineer, for certain improvements in steam-engine, steam-boilers, and safety valves, and in apparatus and machinery for propelling vessels.—June 19

Isaac Hartas, of Wretton Hall, York, farmer, for improvements in machinery for obtaining motive power. (A communication.)—June 19.

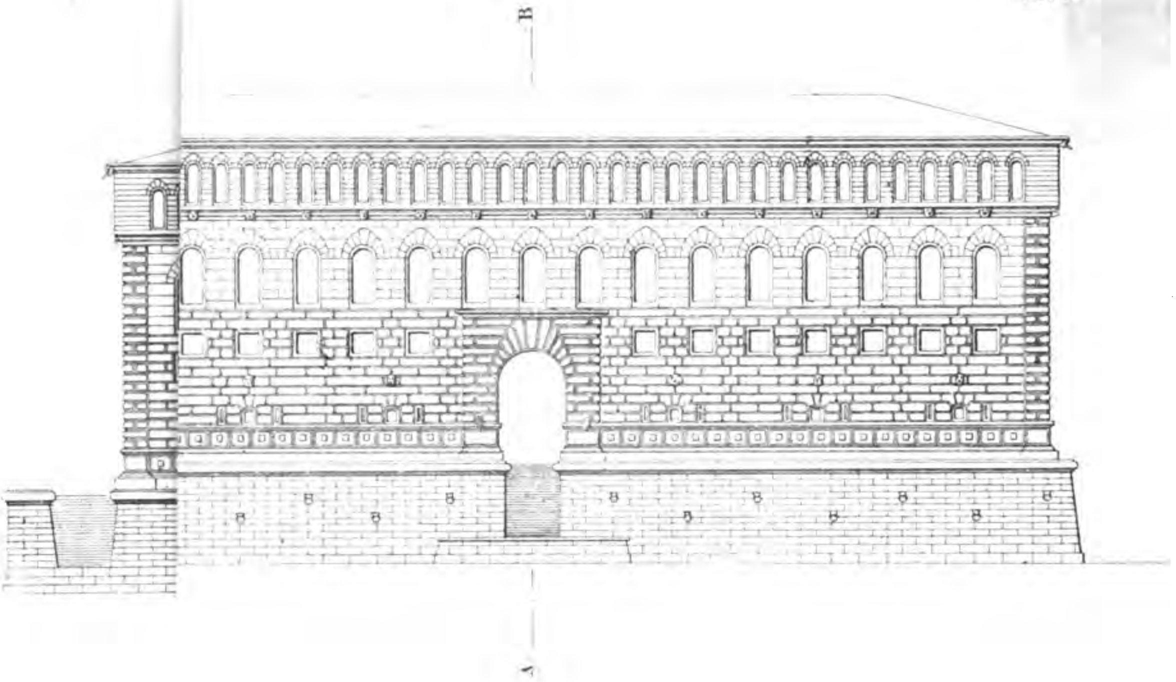
Robert Heath, of Manchester, iron merchant, and Richard Hendley Thomas, of Woolstanton, Stafford, engineer, for certain improvements in the manufacture of iron.—June 19.

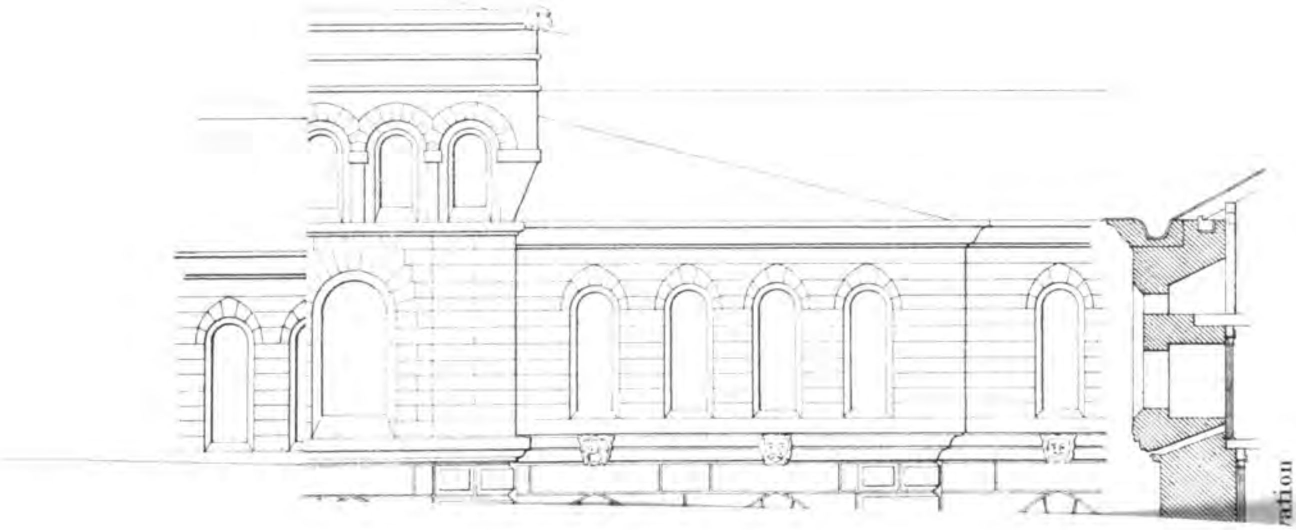
Ethan Baldwin, of Philadelphia, Pennsylvania, United States of America, for a new and useful method of generating and applying steam in propelling vessels, locomotives, and stationary machinery.—June 19.

Robert Weare, of Angel-court, Throgmorton-street, clock and watch manufacturer, for certain improvements in the means and apparatus for extinguishing fire, and in galvanic batteries.—June 19.

George Roberts, of Tavistock, Devon, gentleman, for certain improvements in clogs and pattens.—June 19.

Gaspard Malo, of Dunkirk, France, shipowner, for certain improvements in propelling vessels.—June 20.





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CORN MAGAZINE AT NOVOGEORGIEVSK.

(*With an Engraving, Plate* IX.)

The chief trade in Russian Poland is in the supply of wheat, as is well known to those accustomed to corn-law discussion, and it is an incident of that trade to be subject to very great fluctuations. For the whole of the exports Dantzic is the port, receiving the produce by the Vistula and its affluents, the Bug and the Narew, and the harvests from Cracow to Thorn, and being the only place of shipment. The trade at Dantzic is, to a great extent, carried on with England, and by English houses, or with English means; and in cheap years the Polish corn is bought up, and was formerly kept in the granaries of Dantzic until a favourable state of the market and duty here allowed of its shipment; but now that the Customs restrictions are removed, cargoes are bought in Poland, and warehoused here. However beneficial it is to the English merchant to buy in the cheapest market and sell in the dearest, yet, to the Polish landowner or tax-payer it is a matter of great moment, and therefore of no less to the Russian government, that he should not be forced, by his necessities, to sell at the lowest price to the English agents. The Emperor of Russia, taking this state of affairs into consideration, issued an edict, decreeing, that on various points of the Vistula magazines shall be established, in which, during low prices of corn, every one shall have leave to warehouse grain, and by means of the Polish Bank, obtain advances, so as to be in a position to hold out until a better market can be obtained.

In pursuance of this edict, a point was chosen at the junction of the navigable Narew with the Vistula, close to the fortress of New Georgievsk, formerly called Modlin, and 22 miles from Warsaw. The Emperor directed that a magazine should be established there, with the double purpose of being a corn warehouse to receive the produce of the Bug, the Narew, and the Vistula, on the way to Dantzic, and of being a granary for the fortress of New Georgievsk, which is one of the largest garrisons in Europe. The execution of this project was put under the direction of what is called the Polish Bank, an institution somewhat after the Birmingham model, which issues paper money, and forms trading establishments, among which is an ironfoundry and factory. The building was likewise to serve the purposes of the Bank, by giving it a place of deposit for the crops on which advances were made.

The place chosen is on a tongue of land between the rivers Narew on the right, and Vistula on the left; and which being subject to the inundations of the two streams, is insulated during much of the year. On the right bank of the Narew is the town of Modlin and citadel of New Georgievsk. Under its guns, in the middle of the waters, is the warehouse. On the left bank of the Vistula, commanded by the citadel and the warehouse, is a large outwork, to keep up the communications.

The directions of the Emperor were, that not only a warehouse should be built, but that its lower story should be bomb-proof, in casemates, and pierced with embrasures, to carry guns both on the side of the Vistula and the Narew. The architect charged with the direction of the work was Mr. Jacob Gay, though of what nation he is we are unaware.

The situation, as we have intimated, is very low, with a slimy soil, and occasionally flooded by both rivers. It, therefore, became necessary to lay the foundations on firm pilework, the more particularly as they were to carry enclosure walls of unusual thickness, and a building of five stories in height. Besides, it was necessary to provide an embankment on the Narew side, on which the Warehouse could be placed above the greatest rise of the water, which, in 1813, was 23 feet. In order to provide against any further extraordinary flood, and the upheaving of great blocks and flakes of ice accumulating in the neighbouring islands of the Vistula, it was resolved that the lowest floor should be laid two feet above the water-mark of 1813.

The first works began in 1835, and the driving of the piles and laying of the foundations was entrusted to Heer J. Singhels, an engineer from Holland, then in the service of the Polish Bank. He began with a fascine-dam in the bed of the Narew, 20 feet from the line of the foundation. The piles driven under the front walls and piers were 2800 in number, each 30 feet long and 10 inches square, shod with iron. These works were carried out in the winter of 1836 and summer of 1837, at the time of the lowest water, which varies very much in the Vistula, for though at some times of the year boats drawing more than two feet water cannot navigate it, yet it will suddenly rise 20 feet.

In order to carry on the works as free from water as possible, a 12-horse power steam-engine was set up, and kept pumping day and night, until the foundations were got six feet above the level of the water. In the month of March, 1837, the height of the foundations had reached 10 feet above the water level, when an unexpected flood, which rose 15 feet, burst into the works, and suspended them. On the waters falling, a fortnight after, it was found that the walls and arches of the foundations were in nowise injured, but that the chief mischief was in carrying off some of the materials prepared. In the autumn of 1837 the embankment and foundations were fully brought to an end. The whole embankment on the Narew side is faced with strong sandstone, from some very rich quarries lying on the Vistula, about 150 miles from Warsaw. This stone has been likewise much used in other parts of the construction. The smallest stone used for facing the embankment or retaining wall, is 8 feet long, 2 feet broad, and 1½ feet thick. The thickness of the walls behind the sandstone and the inner foundation are of mountain granite, with strong layers of hydraulic lime, and all hollows and interstices of the stone are filled in with broken granite and hydraulic lime.

The inner foundation is carried on piers of granite and arches of brick set with hydraulic lime, and each pier is bonded with iron thrice in its height. All the foundations are filled-in with earth to the height of the embankment, as cellar room is not wanted, and the whole space before the warehouse on the Vistula side is raised by filling to the same height as the quay wall on the Narew, and secured where it lies against the stream of the Vistula by a dam 200 rods long, constructed on the most approved plan of those in Holland. On the top of the basement wall, which batters, is a balcony of cast-iron, and on the wall are strong hooks for making fast barges and boats.

The cost of the basement wall and embankment was 23,000*l.* (155,000 silver roubles), and in consequence of numberless unforeseen difficulties, exceeded the estimate by 9000*l.* In April, 1838, Mr. Gay began the building of the magazine, and having the materials ready prepared, and the labour of 250 Russian masons, the vaulting-in of the bomb-proof casemates was effected in the July following.

In the same month the building was inspected by the Emperor, and he gave permission for several deviations, which Mr. Gay's experience had pointed out. In November, 1838, the whole building was roofed-in, and most part of it covered with zinc against the approaching winter, so that in the ensuing year nothing was expected to be done but the completion of the roofing and the laying of the floors. In the course of 1838 they used up 11,000,000 bricks, 60,000 cubic feet of sandstone, and above 3000 logs, 40 feet long and 10 inches by 12.

The preparation of these materials was attended with considerable difficulty, as the neighbouring fortress was likewise in progress, and for which 50,000,000 bricks were yearly required; besides which, the site of the building was confined by the waters, and all the materials had to be raised from the river to a height of 60 feet by slow and toilsome labour. Single blocks of sandstone for the vaulting of the gateways, for corner stones, and for the cornice on which the fourth and fifth floors rest, and which measured 30 or 40 cubic feet, were dragged up from the barges in the Narew by the physical strength of the Russian masons.

The progress of the works was slower in 1839, but on the 13th of July the building was near its completion, when the roofers, at a time when a gale was blowing, by some want of care, let red-hot coals fall on the woodwork of the roof, which catching, fire spread throughout the building, and in four hours all that was consumable was in ruins. On subsequent examination it was found that none of the walls of brickwork had lost any of their strength, although the beams which kept them together had been burnt through. The bomb-proofs received no injury. The sandstone on the Vistula façade was the most affected. The whole cornice on which the overhanging upper floors rest was so much injured as to require many repairs. It was small consolation to the architect in such vexation to find that the construction of his walls was good under an unexpected proof, but he had at least the comfort of being entrusted with the re-construction.

In the re-construction, iron columns were in many cases introduced to carry the girders, and Mr. Gay found it necessary to remove many of the blocks in the cornice which had been injured by the fire. For this purpose a scaffolding was put up, the injured stones taken out, and new ones put in. At last, these and the other works were carried out and completed; and the magazine being filled with wheat, and the guns on the lower story being fired, the building was found to stand all tests, and it is said to have since remained in a good condition. In the summer of 1840 the completion was announced, and the Emperor was shown over the building. The whole cost, from the foundation upwards, setting aside damage from the fire, was 70,000*l.* (465,000 silver roubles) and the excess over the estimate was 4500*l.* (30,600 silver roubles), caused by heavier wages to labourers, and rise in the price of materials.

In the middle of the building is a doorway and passage, which is likewise bomb-proof, and which reaches through two stories, as well as the ground-floor. In this gangway is a moveable granary, the invention of M. Valery of Paris, by which a thousand bushels of wheat are cleaned at once. From this doorway, as well as from both others on the Narew side, iron stairs reach to the river, for lading and unlading from the boats. In the windows and on the floors strong cranes are placed. On the Vistula side is only one doorway in the middle of the building, as this façade constitutes a battery to command the Vistula. The length of the building is about 600 feet (600 Polish feet), and the breadth about 100 feet. The height in the wings on the Narew side, with the basement wall, is 90 feet, and on the Vistula side 23 feet lower. After the fire the roof was covered with iron sheeting. The windows in the three stories, and in the lower floor, are made without parapets, and so that fresh air for the ventilation of the corn can be readily admitted. The upper windows, it should be observed, are each divided by a floor, so as to make five stories besides the casemates. The cornice on which the fourth and fifth stories rests, and which is in the Castellated style, projects with the upper wall about one foot and a half. It is decorated with masks of various designs, in sandstone, which serve the purpose of ventilators for the lower part of the fourth story. The whole of the floor of the first story is laid with asphalte, the use of which in Poland was introduced by Stanislas Wysocki, engineer of the Vienna and Warsaw Railway. All the castings were supplied from the works of the Polish Bank in Warsaw.

The building has not the usual appearance of a granary, but being partly of a military character, a peculiar style was adopted, which is not inappropriate, and in which Mr. Gay has chiefly followed the example of the castellated mansions of Florence. It thus acquires a bold and monumental character, worthy of its massive construction, and may justly be ranked among the finest buildings in Russia, of which so many distinguish the present government, and as being without a parallel in Europe.

The seat of the magazine is one of the strongest points of the system of fortification, and it rises above the two rivers and the waters of the inundation, with its images glittering in the streams on a fine day with a most picturesque effect. On the opposite shore of the Narew is the citadel, and some long lines of barracks, on rising ground about 80 feet high; and the two banks are united by a temporary wooden bridge, which is hereafter to be replaced by a suspension bridge. The width of the Vistula is about 1700 feet (and which can likewise be bridged), and that of the Narew 900 feet. The town and fortress communicate, by paved roads on each side of the Vistula, with Warsaw; and when the water permits, two steamboats run.

For this information, and for the engravings, we are indebted to the *Bauzeitung*; and we only regret that we are not in possession of more practical details.

LECTURES ON THE HISTORY OF ARCHITECTURE;

By Samuel Clegg, Jun., M.I.C.E., F.G.S.

Delivered at the College for General Practical Science, Putney, Surrey.

(PRESIDENT, HIS GRACE THE DUKE OF BUCCLEUCH, K.G.)

Lecture VIII.—*The Parthenon—Erechtheion—Theatres, &c, Domestic Architecture of the Greeks.*

The Parthenon was commenced about 448 B.C., on the site of the old temple called the Hecatompedon, which was destroyed 32 years before by the Persians under Mardonius. It was situated on the highest ground in the Acropolis, where it stood a masterpiece of art. Dr. Clarke says: "To a person who has seen the ruins of Rome, the first suggestion made by a sight of the buildings in the Acropolis is that of the infinite superiority of the Athenian architecture: it possesses the greatness and majesty of the Egyptian or of the ancient Etruscan style, with all the elegant proportions, the rich ornaments, and the discriminating taste of the most splendid era of the arts." "In all that relates to harmony, elegance, execution, beauty, and proportion," he continues, "the Parthenon stands a *chef d'œuvre*; every portion of the sculpture by which it is so highly decorated has all the delicacy of a cameo." This temple of the Doric order, octastyle and peripteral, may be considered as a perfect example of the principles of Greek architecture, the harmony of proportion and the severe uniformity of its masses blending and contrasting with the endless diversity of line and curve formed by the sculpture with which it is adorned. The charge of its erection was committed to the architects, Ictinus and Callicrates, under the general superintendence of Phidias. The beasts of burden employed in carrying up the materials were thenceforward exempted from any less sacred work; and one that had voluntarily headed the train was kept at pasture during the rest of its life at the public expense. The whole of this magnificent edifice was constructed of Pentelic marble; no cement was used, but the margins of the blocks were polished, so as to fit with greater exactitude—a style of masonry that, from its beauty, was called by the Greeks "*harmonia*." The blocks composing the columns (including the capitals) were twelve in number. They were united by a cylindrical wooden pin, inserted into a plug about 5 inches square and 3 inches deep, let into a corresponding mortice in the blocks. The dimensions are 227 feet by 101 on the upper step. It consisted, besides the Pronaos and Posticus, of two apartments, the Cella and the Opisthodomos. The former or eastern chamber is 62½ feet in breadth, and 98 ft. 6 in. in length; the western chamber is 44 feet in length. The total height of the temple, from the stylobate to the summit of the pediment, is 65 feet. The exterior columns (eight in each portico, and seventeen along the flanks, including those at the angles) are 6 ft. 2 in. lower diameter, and 35 feet in height. The ambulatory is 9 feet in width. Vitruvius advises that, in order to correct the delusion caused to the eye by the apparent deviation of a long horizontal line, the stylobate should be slightly raised towards the centre, and that the architrave should descend with a corresponding curve. He also directs that the axes of the columns at the angles and along the flanks should be inclined, the faces next the walls of the cella being perpendicular to the stylobate; so that the whole diminution of the shaft should be given to the exterior. Both these rules have been observed in the erection of the Parthenon, a fact discovered by Mr. Pennethorne. The upper step in the eastern front forms a curve, rising 3 inches in the centre; the architrave also curves, the curve being increased in the cornice. The columns of the peristyle incline inwards 1½ inch from the perpendicular. The ceiling of the Opisthodomos was supported by four columns of about 4 feet diameter. This apartment was the treasury of Attica and her allies. The Prytanes kept the key of the Opisthodomos, as well as that of the Acropolis; one of these officers was chosen by lot, and was entrusted with the keys for one single day and night, during which time he was called the Epistates, or president; when his term of duty had expired, the charge passed to another of the same body. The treasures belonging to the temple, consisting for the most part of votive offerings, were of great value. Pausanias mentions the dedication of golden shields; and Alexander the Great, after the battle of the Granicus, sent 300 suits of Persian armour as offerings to Minerva in the Parthenon. In the interior of the Cella were sixteen columns, of 3 ft. 6 in. diameter; the order employed is uncertain, the only vestige that has been found amongst the ruins being one mutilated Corinthian capital. Mr. Lucas, by a careful measurement of the marks left by the bases, and a comparison of the information attainable on the subject, has concluded that the lower range of interior columns must have been Ionic, and the upper Corinthian; and has thus restored it in his model in the British Museum. The interior apartments and the vestibules are raised two steps from the stylobate; six columns *in antis* of 5½ feet diameter led into the vestibule at either end of the building. The central part of the Cella, as in all the temples to the superior divinities, was hypæthral. Here stood the great statue of Minerva, wrought in gold and ivory by the hand of Phidias; it was 39 feet in height, exclusive of the pedestal, and carried a golden spear 40 feet in length. When Phidias returned from Elis, the enemies of his patron Pericles, accused him of peculation in regard to the gold employed on the statue. Fortunately, by the advice of Pericles, Phidias had formed the gold plates so that they could be taken off and weighed; and by this means the foul calumny was refuted; but his accusers, determined not to be again foiled, brought a charge against him of impiety, alleging that he had introduced portraits of Pericles and himself on the shield of the goddess. He was upon this thrown into prison, where he died, as some assert, by poison, just as the last great work of Pericles, the Propylea, was completed (432 B.C.) As Mr. Lucas observes, "The embellishments of the Parthenon are an epitome of the history of the people, alike in their religion, their patriotism, their deeds of valour, and the religious ceremonials of their existence." The sculpture of the two pediments represents on the one the birth of Minerva, or her presentation to the gods of Olympus; on the other the contest between Minerva and Neptune for dominion in Athens. The subjects on the metopæ were taken from the most celebrated conquests of the Athenians; and on the frieze surrounding the exterior of the Cella, the Panathenaic procession was represented. Nor were the embellishments confined to sculptûre alone. Under that unclouded sun, Nature exceeded in brilliance and vivacity everything that man could produce, and so allowed the use of polychrome ornament to an extent that, in our murky atmosphere, would appear gaudy and unpleasing. The statues in the pediment, and the bas-reliefs on the metopæ and frieze, were brought out against a ground of azure blue; the tenia and regula, the fascias underneath the mutules; the cyma and ogee mouldings, and the lacunaria, were richly coloured; causing the columns, triglyphs, and principal parts of the cornice to appear more dazzlingly white from contrast. Along the architrave gilded shields were suspended, and between each shield was an inscription in brazen letters; thus, the Parthenon, standing on its lofty platform of rock, with its gleaming columns, its rich and harmonious colouring, its shields glittering like stars as they caught the sun's rays, would appear to the imaginative Greek a fitting abode for the virgin goddess, and was peculiarly appropriate to the gorgeous ceremonials of the Pagan religion.

The Erechtheion was commenced about 409 B.C., and completed 393 B.C. In this beautiful temple the Ionic order is carried to its greatest perfection. The plan is singular: it most resembles the prostyle, but with the addition of a portico at each side, one to the north, the other to the south, extending the western front. It is a double temple, dedicated to Minerva Pollias, as protectress of the city, and the nymph Pandrosos; it is also supposed to be the burial place of Cecrops.

A tradition from the mythology of Athens, quaintly related by Mr. Chandler, accounts for the union of the two shrines under one roof. "Minerva entrusted to Aglauros, Herse, and Pandrosos, a chest, which she strictly enjoined them not to open. It contained Erechtheus, or Erecthonius, an infant, the offspring of Vulcan and of the Earth, guarded by a serpent. Curiosity prevailing, the two elder sisters disobeyed. The goddess was gone to Pallene for a mountain, intending to blockade the entrance of the Acropolis. A busy crow met her on her return, and informed her what had passed, when she dropped the mountain, which was afterwards called Lycabetus; and, displeased with the officious talebearer, commanded that no crow should ever again visit the Acropolis. The guilty sisters were seized with a phrenzy, and threw themselves down one of the precipices; Pandrosos was honoured with rites and mysteries, she was joined with Minerva, and when a heifer was sacrificed to the goddess, it was accompanied with a sheep for Pandrosos."

The Erechtheion contained the most ancient statue of Minerva, said to have fallen from Heaven, in the reign of Erechthonius, king of Athens. Before this statue was the ever-burning golden lamp, the work of Callimachus. Here also was the sacred olive tree, called forth by Minerva in her contest with Neptune. In the small portico to the south, the entablature is supported by figures, generally called Caryatides; but as these seem to represent Athenian maidens in their Panathenaic costume, Canephoræ, or basket-bearers, is the more appropriate designation. Examples of such supporting figures are very rare in Greek art. The earliest is supposed to have been a brazen cratera, in the Temple of Juno at Samos, which was upheld by three kneeling colossi, 10 ft. 6 in. in height. It was dedicated about the year 640 B.C. by a Samian, of the name of Colæus, who was driven by contrary winds beyond the Pillars of Hercules; but having found a port at Tartessus, now Cadiz, and disposed advantageously of his goods, he and his crew, on their return, consecrated a tenth of their profit to the erection of this monument. A copy is supposed by Visconti to exist in a fountain, supported by three Sileni, in the Vatican.

Vitruvius gives the following account of the origin of Caryatides. "Carya, a city of Peloponnesus, took part with the Persians against the Grecian states. When the country was freed from its invaders, the Greeks turned their arms against the Caryans; and, upon the capture of their city, put the males to the sword, and led the women into captivity. The architects of that time, for the purpose of perpetuating the ignominy of this people, instead of columns in the porticoes of their buildings, substituted statues of these women, faithfully copying their ornaments and the drapery with which they were attired, the mode of which they were not permitted to change."

It is however generally thought that Caryatides owed their origin to the worship of Diana, and were intended to represent nymphs. In Lacedæmonia this goddess was worshipped under the name of Diana Caryatis; and the neighbourhood of Carya was said to have been consecrated to Diana and her nymphs. The celebrated Persian portico is only known to us by report; but there, apparently, the figures, like the Egyptian osirides, only stood in relief against the supporting pillar. They are said to have been portraits of Mardonia, Queen Artemisia, and other leaders of the Persian host, and erected with the spoils taken from them in battle. Figures thus introduced are seen at Thessalonica, in the building called the Incantada. This is not however of very ancient date. The entablature of the interior of the Cella in the Temple of Jupiter at Agrigentum, was supported by male figures, 25 ft. in height, called by the Greeks, Atlantes. They occupied the position of the upper row of columns in other hypæthral temples.

The columns of the eastern and northern porticoes of the Erechthion are exquisite in design and execution. The volutes are formed by a double spiral, and the lower band of the channel between takes a graceful curve. Beneath, between the volutes, is a plaited torus, and below this a wreath of honeysuckle ornaments. To the capitals of the eastern portico a beading, like a string of pearls, is added. The upper tori of the bases of the columns of this portico are fluted; while those in the northern portico are ornamented with a guilloche. The columns of the eastern or hexastyle portico are 9½ diameters in height, and the intercolumniations are a fraction over two diameters, or nearly systile. Those of the tetrastyle, or northern portico, are rather less slender; and the intercolumniations are increased accordingly, being two and three quarters diameter, or nearly diastyle. These columns are raised upon a podium, as are also the Caryatides of the Pandroseion. The capitals of the columns at the angles were singularly ornamented with coloured stones, black, blue, and yellow, let into the small circles formed by the plating on the torus, between the volutes; and bronze plugs in the eyes of the volutes appear to have been intended to support further embellishment, probably garlands, with which it was the custom of the Greeks to adorn their temples on festive occasions. The eyes of the volutes in the Temple of Minerva Priene, are bored 2½ inches in depth, most likely for the same purpose.

The Erechtheion was decorated with different coloured marbles. Fragments of columns of verd antique have been found in the interior; and the frieze of the eastern portico, as well as the tympanum of the pediment, is of grey Eleusinian stone. In the western wall of the cella are three windows, contracted towards the top. These divide four Ionic engaged columns, somewhat exceeding the semicircle, so that the last fluting is perfect. The channel of the fluting is slightly increased at the top, and diminished at the bottom, in order that the fillet attached to the wall may be perpendicular. In this temple is the only doorway now remaining amongst the ruins of Greece. Like the windows, it contracts towards the top: it has beautiful consoles, and is ornamented with open roses along the jambs, and wreaths of holly-leaf on the mouldings. Detailed drawings of this doorway are given by Mr. Inwood, in his work on the Erechtheion. The doors of Greek temples were generally constructed either of bronze or of wood, and perforated at the top to admit light. Mention however is made of the door of a temple in the wealthy city of Syracuse, which was of ivory and gold.

Before bidding farewell to the Acropolis, we must pause a moment before the great Propylea; though Phidias had the general superintendence of the works of Pericles, each building appears to have had its separate architect; the Propylea was the work of Mnasicles, and occupied five years in its erection. This structure, consisting of a vestibule with two wings, extended across the whole natural entrance to the Acropolis, a space of 168 feet. The propylæum or great vestibule, occupied 58 feet in the centre; the two wings enclosed the remainder, and extended 32 feet in front of the entrance. The portico of the vestibule was supported by six Doric columns, 5 feet lower diameter, and nearly 25 feet in height; the intercolumniations were 7 feet, excepting between the two centre columns, where a space of 13 feet was left, to allow of the passage of chariots: the level of the vestibule was gained by four steps. In the interior the roof was supported by six Ionic columns in two rows; this order was adopted in the interior on account of the greater elevation it allowed to the ceiling; this was laid upon marble beams, extending from the side walls to the columns, and from column to column: the length of the centre beams was 17 feet, of the lateral ones 22 feet. The vestibule was entered by five doors of bronze, the centre one corresponding in size to the middle intercolumniation: those at either side diminished both in height and width, and the two last were smaller still. The portico in the rear was similar to the one in front, except that it stood upon a higher level, being raised five steps above the entrance; one step in descent led from it to the platform of the Acropolis. The wings were finished at the extremities with antæ, and a frieze with triglyphs; in the flanks were three Doric columns *in antis*, each 3 feet diameter. In the northern wing was a chamber, in the southern an open gallery, with a narrow passage leading into the Acropolis by a postern gate. There is no doubt that the Propylea was intended as a means of defence as well as an ornamental entrance, and answered the same purposes as the pylons of the Egyptian temples. The Propylæa at Eleusis, Sunium, and elsewhere, were erected after this model, but consisted merely of a vestibule without wings, and formed a grand entrance to the peribolus of the Temple. The extent of the interior of the vestibule, and the quantity of light admitted, allowed great scope to the decorative artist. The lacunaria and mouldings of the Propylea at Athens were splendidly adorned with colours and gilding; the coffers of the soffits were spangled with gold stars on an azure ground, and the antæ enriched with a delicate wreath of ivy leaves. The roof and pediments of the Propylea were destroyed by the Venetians, A.D. 1687.

Next in importance to the sacred edifices were those appropriated to public amusements. The savage games of the amphitheatre were unknown to the refined and intellectual Greeks until after their subjugation to Rome. When the Roman Emperor caused gladiatorial combats to be exhibited in the Agora of Athens, the philosopher Demonax observed that it would first be necessary to throw down the altar to Mercy that stood there. Dramatic entertainments appear to have been the great delight of this highly cultivated people, and consequently in all Greek cities the ruins of extensive theatres are found. These structures were not used exclusively for the representation of the drama, however, for public assemblies were frequently held there; St. Paul addressed the Ephesians in the theatre; and the theatre of Syracuse, as we learn from ancient authors, was constantly so employed. Theatrical exhibitions originally commenced in a rural chorus celebrating in the fields the festivals of Bacchus and Ceres. Dramatic recitations first took place on a rustic wagon, next on a moveable wooden platform; but during a contest for the dramatic prize between Æschylus and Pratinas, the concourse of people flocking to witness the performance caused a serious accident, by the breaking down of the temporary theatre: this was the cause of one of more solid materials being erected; and painted scenery was now first introduced by Agatharchus, instructed by Æschylus. Vitruvius recommends that theatres should not have the concave part towards the south, on account of the heat, and that they should be built in a healthy situation. "For," says he, "those who frequent them, in company with their families, engaged by the interest they take in the representations, remain in fixed attention; whence it happens the pores of the body are exposed to the effects of the atmosphere, which, in the neighbourhood of marshes and spots otherwise unhealthy, is charged with vapours prejudicial to the human frame." The form of the Greek theatre was that of a segment of a circle, sometimes being more than the semicircle—sometimes with the sides continued in parallel lines, terminated by a parallelogram extended across the base. It consisted of three principal parts, the Coilon, containing the seats for the spectators; the Orchestra for the musicians, dancers, and chorus; and the Logeion or proscenium, for the principal performers. This was again divided into three parts; the Hyposcenium, on which the actors recited; the Scene itself, on which the decorations were exhibited; and the Parascenium, or enclosures behind and on each side of the Scene, containing apartments for the accommodation of the performers, and the preservation of the stage property. The Coilon was composed of rows of seats, rising one above another, separated at intervals by præcinctiones, or passages, and by radiating flights of steps, and bounded at each extremity by a podium. This part of the theatre was almost always formed on the side of a hill, advantage being taken of the natural elevation, to save labour and expense; indeed, there are only two instances in Europe, and one in Asia Minor, of theatres built on level ground. The rows of seats between the passages were appropriated to different ranks of spectators, and above the upper corridor there was frequently a gallery for the accommodation of women and strangers. A covered portico extended round the summit of the Coilon, the entablature of which was level with the upper members of the elevation of the Scene. The Orchestra was generally concentric with the Coilon, and of considerable extent, as the drama alone was exhibited on the stage, other performances, such as singing and dancing taking place in the orchestra; hence the actors were respectively called either scenici, or thymelici. The Orchestra had a separate entrance; in the centre stood a platform, called the Thymele, which served as an altar, on which sacrifices were offered to Bacchus; and around were placed the tripods, crowns, and other prizes for the victorious dramatist or choragus. Steps led from the Orchestra to the Logeion; when the theatre was used as a place of public assembly, this part was occupied by the orators. Between the acts of the drama a curtain was let down before the Hyposcenium, or stage, during which time the chorus in the Orchestra entertained the spectators; underneath was the machinery used to produce thunder and other effects. The Hyposcenium, with its decorations, was generally constructed of wood, so that, of course, no vestiges of this part of any ancient theatre remain. The permanent Scene represented the exterior of a palace, and was used for tragic performances. As the Greeks never admitted strangers into the domestic privacy of their houses, it would have been deemed a breach of propriety to picture the interior on the stage. In the Scene were three doors; the centre one was magnificently decorated for the admission of the principal personage of the drama; near it was placed a circular altar, dedicated to Apollo, and a table spread with consecrated cakes and sweetmeats: the door on the right was plain, like that of a private dwelling—where the second actor entered; while that to the left, generally a mere opening, was for the inferior performers. When comic or satiric pieces were to be represented, painted scenes were added; in the former, exhibiting the exterior of a private residence, with windows and balconies; and the latter, pastoral subjects, with mountains, trees, and caves formed of grotto work. The Greek drama was recited rather than acted, three or four performers only appeared on the stage at one time, and these seldom crossed each other, or changed their places; the stage, therefore, was of little depth.

Vitruvius speaks of the Orchestra being divided into twelve equal portions, the same method practised by astrologers in dividing the zodiac into twelve constellations, "from a belief," he says, "that a musical concordance exists in the disposition of the stars." He also mentions modulating vases, of earth or metal, placed in two or three rows under the seats, to assist in extending the voice of the performer; they were in the form of an inverted bell, and were modulated to intervals according to musical proportion; so that when the voice was pitched to a certain interval, the vases vibrated in unison, and so carried on the sound. They were placed on pedestals, about 6 inches high, and an aperture was left in front of the seat, about 2 feet in length, and 6 inches in height. It is said, that when Lucius Mummius destroyed the theatre at Corinth, he dedicated a temple to Luna out of its spoils, and, amongst other things, brought away a number of these brazen vases. The Scene communicated with the lower chambers of the Parascenium by the before-mentioned doors; this part consisted of several stories. On the exterior was a portico with a double row of columns, where the audience found shelter in case of a sudden shower. The exterior columns were generally Doric; the interior Ionic, one-fifth higher. The columns were more slender, and the ornaments more fanciful and elaborate in the theatre than in sacred buildings, according with its festive intention. The space in front was laid out in walks, and planted with trees and flowering shrubs, so that the portico of the theatre was a pleasant place of resort for the loungers of ancient Greece. In early times there was no awning stretched over the Coilon, the voluptuous Sybarites having first introduced this luxury: the spectators, therefore, on sunny days, had to carry umbrellas, which must greatly have impeded the view; the ladies were attended by umbrella-bearers. The Dionysaic Theatre, at Athens, had seats for 30,000 persons: those of Sparta and Argos were 500 feet diameter; and the theatre in the Grove of Æsculapius, at Epidaurus, built by Polycletus, 360 feet diameter.

Near the great theatre there was generally an Odeion, so called from *odè*, a song; a smaller building, of similar form, but roofed; it was used for the purpose of musical entertainments, and for the rehearsals of the chorus. The Odeion of Pericles, at Athens, had a wooden tent-shaped roof, constructed with the masts and yards taken from the Persian ships; this was destroyed by Ariston (86 B.C.) that Scylla might not make use of the timber in his siege of the city. In Athens it was the custom for each of the demi, or tribes, to appoint a choragus, who was to conduct a chorus at the musical contest held at the Festival of Bacchus: the prize was a tripod, and the victorious choragus usually erected a monument on which to place it; this was the origin of the street of tripods. Two of these choragic monuments are yet standing, those of Thrasyllus and Lysicrates; the former of the Doric, the latter of the Corinthian order. The following was the form of dedication: "Thrasyllus, son of Thrasyllus of Deecleia, dedicated the tripod, having, when he provided the chorus, conquered with men for the tribe Hippothoontis; Evius of Chalcis was musician; Neœchonus was archon, Caraidamus, son of Sotis, was teacher." The Corinthian capital of the monument of Lysicrates has been already described; the conical roof is thatched with marble tiles in the form of laurel leaves; from the apex rises an elaborate floral ornament, on which the tripod was placed. This elegant little monument was erected 335 B.C.

Besides the temples and theatres, ruins of other extensive structures are found in most of the cities of Greece. There was the Palæstra and the Gymnasium for the practice of athletic exercises; the Stadium for foot races, wrestling, throwing the disc, and other public games; and the Hippodrome for horse and chariot races. The Palæstræ were buildings containing baths, and apartments for instruction and other purposes, surrounded by porticoes. Sometimes, as at Ephesus, the porticoes were inclosed by a wall, forming what was called a cryptoporticus; sometimes, as at Alexandria Troas, they were open all round. Within the porticoes were spacious exhedræ or recesses, containing seats, where philosophers, rhetoricians, and other learned professors met to converse. In winter, or in stormy weather, the athletæ practised beneath the portico; a space was left along the centre 12 feet in width for the gymnastic sports, the margins being raised several steps above it as footways, so that persons could pass, or stand to watch the athletæ without being incommoded by them; in the Palæstræ were frequently double porticoes, called by the Greeks systylos; these were divided by open walks, planted with trees and furnished with seats. The Stadium was an open space in the form of a parallelogram, with one end terminating in a semicircle; the Hippodrome was similar in form, but of greater extent; a podium or spina, as it was called, adorned with altars and statues, extended along the centre; round this the chariots turned in the race. The Hippodrome at Olympia was the largest in Greece; here as many as forty chariots ran at one time. The Hippaphesis of this course, or place from which the horses started, was so celebrated, that the architect placed the following inscription on a statue he afterwards executed at Athens: "Kleöitas, son of Aristocles, made me, the same who first invented your Hippaphesis, O Olympia!" Pausanias has left us a description of this structure; he says, "The Aphesis presents the appearance of the prow of a ship, of which the beak, or embolus, is turned towards the course. At the side where the prow abuts on to the portico called Agnamptus, it becomes wider. A dolphin of brass is placed on a bar at the extreme point of the beak. Each side of the Aphesis is more than 400 feet in length; in these stalls are constructed, which those who enter for the horse race portion out by lot among themselves. Before the chariots and the horses a cord is stretched by way of a barrier. About the middle of the prow is an altar of unburnt brick, which, every Olympiad, is covered externally with dust; upon the altar stands a brazen eagle with its wings extended. When the person to whom the duty is intrusted has put in motion the machinery by which the eagle is directed, it springs up so as to become visible to all the spectators; then the brazen dolphin sinks to the ground; the cords which are on both sides of the portico of Agnamptus are let loose, the horses that are in these stalls advance first, and when they come in a line with those to which are allotted the stalls of the second rank, the cords that restrain these are also loosened, and the same order is observed by all the others until they are all drawn up in an equal line at the beak of the prow; and here follow the display of the skill of the charioteers, and of the swiftness of the horses."

Public business and traffic of all kinds was carried on in the Agora, a large space something between the great square or *place* of modern continental towns, and an oriental bazaar. The old Agora at Athens was situated in the inner Ceramicus, and extended over the hill of the Areopagus; here were warehouses and shops in different divisions, according to the trade carried on, and receiving their names from the commodities on sale. Here also were extensive porticoes or stoæ; that called the Pœcile, adorned with fresco paintings of the battle of Marathon, was the resort of the stoic philosophers, whence they took their name. Numerous statues of the heroes and benefactors of Athens adorned the place; to some of these a copy of every new law proposed was appended previous to discussion. Many important public buildings also stood within the limits of the Agora; among the rest the Bouleetereion, or council-chamber, where the senate of five hundred met to discuss measures before they were laid before the general assembly of the people in the Pnyx; and the refectory of the Prytanes or presidents of the assembly, where the most distinguished Athenian citizens were entertained at the public charge. In the centre of the Agora stood an altar dedicated to the twelve principal divinities; this was the point from which the different roads of Attica diverged, and from which distances were measured. The new Agora was to the north of the Acropolis, in the quarter called Eretria; near this was the Tower of the Winds, or Horologia of Andronicus Cyrrhestes, erected 159 B.C. It is a small octagonal building of the Corinthian order, surrounded by a frieze, on which figures emblematic of the winds are carved in bas-relief, one occupying each side. Beneath these lines are traced, with styles fixed above; the shadows thrown from the styles upon the lines told the hour of the day; when the sun was obscured, a clypsedra, or water-clock, in the interior of the building, answered the same purpose. The roof is but slightly elevated, and is composed of twenty-four blocks of marble, cut in the form of tiles, diminishing as they incline to the centre; on the summit a circular block of marble supported the figure of a triton holding a wand, so constructed as to move on a pivot and point in the direction of the wind.

Before speaking of the houses of the living I must make brief mention of the abodes of the dead. None but the greatest heroes were allowed a burial place within the city; but without the gates, each side of the road was lined with monuments. The most usual form was that of a pillar or stelé, bearing the name of the deceased, and often richly sculptured. The palmette, or Greek honeysuckle, is the device most frequently met with. As this ornament does not resemble any known flower, its origin has given rise to many speculations. The recent discoveries in Assyria have, however, thrown new light upon the subject, as we find there the same device in conjunction with the kneeling bull—indeed, with the bull prostrate before it; it is evident that it was some ancient symbol of fire-worship; nor does it require any very great stretch of imagination to suppose it to have been intended to represent the curl of the ascending flame. It was contrary to the principles of Greek art to use decoration without meaning; we may take it for granted, therefore, that as we find it so constantly represented on the stelé of tombs, it was with them also a sacred emblem. It is worthy of remark, that on the more ancient Greek sculptures the palmette is more formal, and decidedly less floral in character. The tendrils and other scrolls were doubtless added merely to give additional beauty after the traditional meaning was lost or disregarded. A more elaborate kind of sepulchre was that called Distega, or double-roofed, consisting of two square chambers; the lower apartment contained the cinerary urns, while in the upper relations and friends were accustomed to meet on anniversaries and stated occasions, to perform rites and pour libations to the manes of the dead. The decoration of sepulchres was at one period carried to so great an extent in Greece, that, soon after the time of Solon, a law was passed at Athens that no more labour should be bestowed upon any place of sepulture than ten men could perform in three days, and that the roof should be plain; the setting up of Hermæ, or statues of Mercury, was also forbidden. Long afterwards it was again enacted by Demetrius, the Phalerian, that no person should have more than one monument, and that the height of the pillar should not exceed three cubits.

Little is known of the private houses of the Greeks. For the most part strict republicans, they had no buildings that could claim the name of palaces. The dwellings of the greatest men were as simple as those of the humblest citizen. Demosthenes thought it a sufficient ground of accusation against Medias, that he had built a house at Eleusis by which all others were cast into the shade. To so great an extent was this simplicity carried under the severe laws of Lycurgus, that the Spartans were forbidden to use any other tool in the construction of their dwellings than the axe and the saw. When King Leotychides visited Corinth, noticing smoothly-wrought beams supporting the ceilings of the rooms, he asked if trees grew square in that country. The houses of the Greeks presented nothing but a plain wall and an entrance door towards the street, the windows opening to the interior courts. The rooms were small, and were merely for the purpose of eating and sleeping, the Greeks both transacting business and pursuing pleasure in the open air, under the numerous porticoes of the city, or amongst the groves of the Academy, Lyceium, and other public gardens. It was, no doubt, on account of the smallness of the rooms that the doors were made to open outwards: the person about to leave the house knocked first, to give notice to those passing outside that the door was about to be opened. According to Vitruvius, the vestibule, cavœdium, and peristyles, were the only parts of the house where a stranger might enter uninvited. The master of the house alone was permitted to enter the gynæceum, or women's apartments. From the street entrance is a passage, terminated by gates. On one side of this is the stables; on the other the porter's lodge. This passage leads into a peristyle or open court, surrounded by a colonnade. This belongs to the gynæceum, where the mistress of the house occupied herself with weaving and embroidery, in the midst of her maidens. Next to this were the rooms common to the household, and those set apart for strangers. The hospitalia, or strangers' rooms, had a separate entrance-gate. Here the traveller was entertained, and enjoyed as much ease as in a modern inn; he was provided with supper and a bed on the evening of his arrival, and the following morning went on his way, after receiving presents of fruit, poultry, eggs, and other such produce. After this was the largest division of the house, containing the great peristyle, and the principal apartments, such as the banqueting rooms, pinacotheca, or picture gallery, &c. The eating rooms contained triclinia, on which the company reclined at their meals; whence the rooms took their name. The women never appeared at table with the men; and into some of the œci they were not even admitted, for which reason they were called andronis. Private houses were mostly built of brick, the walls being plastered or stuccoed, and the lacunaria constructed of wood. It is probable they had an upper story; but the situation of the staircase is unknown. Mosaic pavements have been occasionally discovered, supposed to have belonged to the courts of ancient dwellings. The well-known design of doves drinking from a tazza, is from a mosaic of this description. The great simplicity prevailing in private houses caused the attention of the artist to be wholly directed towards the decoration of temples, theatres, and other public buildings. Perhaps it was for this reason that artists were held in such great veneration by the Greeks, being regarded as men dedicated to the service of the gods and of their country.

For detailed information upon the subject of Greek architecture, I would refer the student to the valuable works published by the Dilettanti Society, and those of Mr. Stuart, Mr. Wilkins, and others, which cannot fail both to interest and instruct.

When I have the pleasure of resuming these lectures after the vacation, I shall begin with the subject of Architecture as practised by the Romans.

[The next lecture will appear in the October number of our *Journal*.—Ed.]

LIST OF AUTHORITIES.

Vitruvius.—Histoire des Arts chez les Anciens, Winckelmann,—Topography of Olympia, Stanhope.—Encyclopedie Methodique.—Architettura Antica, Canina.—Antiquities of Ionia, Dilettanti Society.—Antiquities of Attica, Dilettanti Society.—Antiquities of Athens, Stuart and Revett.—Travels in Greece, Dr. Clarke.—Travels in Greece, Chandler.—Remarks on the Parthenon, Lucas.—The Erechtheion, Inwood.—Antiquities of Magna Græcia, Wilkins.—Antiquities of Sicily, Hittorf.—Topography of Athens, Col. Leake.

METEOROLOGICAL QUARTERLY REPORT.

Remarks on the Weather during the Quarter ending June 30, 1850.
By James Glaisher, Esq., F.R.S., Hon. Sec. of the British Meteorological Society.

The weather during the past quarter has been variable, and at times very unusual. The temperature of the air till April 21 was 4·3° above the average, and this period was free from frosts; from April 22 to May 16 there was an average deficiency of 5° daily temperature; from May 17 to June 9 the temperature was about its average value; it was 8° in excess on June 11, and 13° in defect on the 15th, and during the following night the temperature of the air in many places was below 32°, a very unusual circumstance for the season. From June 18th to the 26th the period was warm, the mean excess of temperature was 6°. Snow has fallen on several days during the past quarter.

The mean temperature of the air at Greenwich for the three months ending May, constituting the three spring months, was 46·6°, being of almost the same value as that of the average from the 79 preceding springs.

For the month of April was 48·5°, exceeding that of the average of the preceding 79 years by 2·8°, and exceeding that of the preceding 9 years by 1·0°.

For the month of May was 51·3°, being 1·3° less than the average of the preceding 79 years, and 3·1° less than that of the preceding 9 years.

For the month of June was 60·8°, exceeding that of the average of the preceding 79 years by 2·8°, and exceeding that of the preceding 9 years by 1·2°.

The mean for the quarter was 53·4°, exceeding that of the average of 79 years by 1·4°, and being less than that of the preceding 9 years by 0·3°.

The mean temperature of evaporation at Greenwich for the month of April was 45·4°; for May was 47·5°; and for June was 54·8°. These values are 1·7° *greater*, 3·0° *less*, and 0·1° *greater* than those of the averages of the same months in the preceding 9 years.

The mean temperature of the dew-point at Greenwich for the months of April, May, and June were 41·7°, 43·4°, and 50·1°. These values are 1·0° *greater*, 4·0 *less*, and 1·8° *less* respectively than the averages of the same months in the preceding 9 years.

The mean elastic force of vapour at Greenwich for the quarter was 0·318 inch, being less than the average from the preceding 9 years by 0·031 inch.

The mean weight of water in a cubic foot of air for the quarter was 3·6 grains. The average from the preceding 9 years was 3·8 grains.

The mean degree of humidity in April was 0·795, in May was 0·765, and in June was 0·702. The averages from the 9 preceding years were 0·808, 0·788, and 0·702 respectively.

The mean reading of the barometer at Greenwich in April was 29·594, in May was 29 714, and in June was 29·886. These readings are 0·114 *less*, 0·071 *less*, and 0·089 *greater* respectively than the averages of the same months in the preceding 9 years.

The average weight of a cubic foot of air for the quarter under the average temperature, humidity, and pressure, was 532 grains, being of the same value as that of the average of the preceding 9 years.

The rain fallen at Greenwich in April was 2·4 inches, in May was 2·3 inches, and in June was 1·0 inch. The falls for these three months on an average of 34 years are 1·7, 2·0, and 1·7 inches respectively. The average daily ranges of the readings of the thermometer in air at the height of 4 feet above the soil was in April 16·0°, in May was 18·9°, and in June was 26·0°. The averages for these three months from the preceding 9 years were 17·4°, 18 9°, 19·4° respectively.

The minimum readings of the thermometer on grass in April was at or below 32° on 12 nights, the lowest was 23°; was between 32° and 40° on 14 nights, and exceeded 40° on 4 nights; the highest reading was 44°. In May the readings were at and below 32° on 13 nights, the lowest was 15 ; they were between 32° and 40° on 11 nights, and on 7 nights the readings exceeded 40°. In June the readings were at and below 32° on 2 nights; the lowest was 29°; they were between 32° and 40° on 6 nights, and they exceeded 40° on 22 nights. At Cardington, as observed by S. C. Whitbread, Esq., the reading of the thermometer on grass in April was 12 nights, in May was 12 nights, and in June was 3 nights, below 32°.

The temperature of the Thames water, from the observations of Lieut. Sanders, R.N., Superintendent of the *Dreadnought* hospital-ship, was 48·4° in April. 54·3° in May, and 63·7° in June.

Solar halos were seen on April 1st at Greenwich, on the 2nd at Stone and Hartwell Rectory, on the 7th at Greenwich and Stone, on the 14th at Stone, on the 17th at Nottingham, on the 18th at Guernsey, Greenwich, and Nottingham; on the 19th at Stone and Nottingham, on the 21st at Hartwell Rectory, and on the 25th at Greenwich and Nottingham; on May 4th at Durham, on May 5 at Uckfield, on the 7th at Durham, on the 13th at Uckfield, on the 14th at Hartwell Rectory, on the 19th at Durham, on the 23rd and 26th at Hartwell Rectory, and on the 28th at Nottingham; on June 2nd at Nottingham and Whitehaven, on the 3rd at Nottingham, on the 4th at Greenwich, Stone, Hartwell Rectory, Nottingham, Stonyhurst, and Durham; on the 5th at Stone, on the 8th at Hartwell House, on the 9th at Stone, Rose Hill (Oxford), and Nottingham; on the 10th at Southampton, Stone, Hartwell House, Cardington, Rose Hill (Oxford), Norwich, and Nottingham; on the 11th at Stone, Rose Hill, Nottingham; on the 12th at Nottingham, on the 14th at Cardington, on the 16th at Stone, Rose Hill (Oxford), and Nottingham; on the 17th at Stone and Aylesbury; on the 18th at Aylesbury, on the 20th at Stone and Nottingham, on the 21st at Stone and Nottingham, and on the 29th at Uckfield and Nottingham.

Lunar halos were seen on April 16th and 17th at Hartwell Rectory, on the 19th at Wakefield, on the 20th at Liverpool, on the 21st, 22nd, and 23rd at Hartwell Rectory, on the 24th at Stonyhurst; on May 20th and 22nd at Uckfield, and on the 26th at Stone; on June 16th at Stone and Hartwell Rectory, on the 18th at Stone, on the 20th at Guernsey, Stone, Hartwell Rectory, and Radcliffe Observatory, Oxford; on the 21st at Jersey, Stone, and Hartwell Rectory; and on the 25th at Uckfield.

Paraselenæ were seen on May 28th at Durham, and on June 20th and 21st at Stone and Hartwell Rectory.

Parhelion was seen on May 21st at Nottingham.

Auroræ Boreales were seen on April 5th at Whitehaven, on April 6th at Durham, on May 12th at Aylesbury, Oxford, Stonyhurst, and Durham; on June 5th at Nottingham, on the 13th at Hartwell House, Ratcliffe Observatory, Oxford, and at Rose Hill, near Oxford; on the 26th near Manchester, on the 27th at Nottingham and at Chesterfield.

Meteors.—At Stone on April 10, at 10 p.m., a meteor shot from Jupiter to γ Leonis; on May 2, at 10 p.m., a meteor shot from Virgo about 4° from Jupiter, and went as far as Jupiter; on May 29, at 10h. 5m. p.m., a meteor shot from α Cygni southwards; on June 4, at 11h. 28m. p.m., a meteor shot from α Ursa Minor (Polaris) to δ Ursa Major; on the 16th, at 0h. 25m. a.m., a meteor shot from the west of β Cassiopeæ, and went 4° north; on the same night, at 0h. 40m. a.m., a splendid meteor, larger than a star of the first magnitude, shot from the west of Capella 10° east of due north, and about 15° above the horizon, and went in a westward direction near to the star 31 Lyncis, leaving a train of blue light of about 20°; a few seconds after a small meteor shot from above Polaris to Cassiopea; on the same night, at 0·45 a.m., a meteor shot from β Serpentis, and went about 5° south; at 1h. 3m. a.m. a meteor shot from ε Bootes to Arcturus; at 1h. 20m. a.m. a meteor as large as a star of the first magnitude, and of a beautiful red colour, shot from ε Ursa Major passed by α Ursa Major, and went as far as γ Ursa Major; on the 20th, at 11h. 42m. p.m. a meteor shot between α Lyrœ and α Cygni; on the 24th, at 11h. 30m. p.m., a meteor, as large as a star of the first magnitude, shot from Arcturus, and went 20° magnetic west, leaving a train of blue light.

On June 4th, at Hartwell Rectory, a small meteor was seen from Polaris to the Pointers, at 11h. 30m. p.m.; on the 21st, a meteor shot from α Lyrœ to α Cygni at 11h. 42m. p.m.; on June 24th a meteor was seen from Arcturus to within 10° of the horizon at 11h. 30m. p.m.

At Nottingham, on May 1st, at 10h. 33m. a meteor of the size of second magnitude star fell slowly down from 30° above south horizon at an angle of 40° to west; another fell downwards 5° south of Jupiter; May 30th, at 10h. 38m., a meteor, size second magnitude, passed nearly horizontally 1½° under Vega, moving to south; June 1st, a globe meteor, size of Jupiter, but less bright, of a red colour, having a well-defined disc, moved from γ through φ Cassiopeæ, ended 30° east of α Persei, duration 1½ minute; on the 3rd another, size third magnitude, blue colour, ill defined, passed from α Cygni through Lacretan at 10h. 30m., and at 10h. 4m. a nearly similar one from λ Draconis through η Draconis.

Thunder-storms occurred on April 2 at Wakefield, Leeds, Liverpool, Stonyhurst, and Whitehaven; on the 8th at Uckfield; on the 10th at Aylesbury; on the 11th at Hartwell Rectory, Stone, Cardington, and Saffron Walden; on the 12th at Uckfield, Greenwich, London, and Saffron Walden; on the 13th at Greenwich; on the 17th at Norwich; on the 20th at Holkham, Nottingham, and Exeter; on the 23rd at Hawarden; on May 7 at Uckfield; on the 13th at Leeds and Hawarden; on the 17th at Uckfield; on the 19th at Derby; on the 22nd at Stonyhurst; on the 23rd at Stone, Hartwell Rectory, Hartwell House, Leinslade (Bucks), Rose Hill (Oxford), Cardington, Saffron Walden, Derby, Nottingham, Liverpool, Leeds, and Manchester; on the 24th at Hartwell House, Rose Hill (Oxford), and Radcliffe Observatory, Oxford; on the 26th at Norwich; on the 27th at Leeds, Manchester, Durham, and North Shields; on the 30th at Hartwell House, Liverpool, and Stonyhurst; on the 31st at Stone, and Rose Hill, Oxford; on June 5th at Wakefield, North Shields, and Durham; on the 6th at Hartwell House, Hartwell Rectory, Leeds, Stonyhurst, Durham, and Whitehaven; on the 7th at Leeds; on the 12th at Helston; on the 13th at Uckfield; on the 16th at Durham; on the 17th at North Shields; on the 25th at Wakefield and Leeds; on the 26th at Guernsey, Helston, Falmouth, Truro, Exeter, Uckfield, Southampton, St. John's Wood, Greenwich, Stone, Aylesbury, Hartwell House, Hartwell Rectory, Leinslade, (Bucks), Saffron Walden, Radcliffe Observatory (Oxford), and Cardington; on the 27th at Guernsey, Jersey, Exeter, Chichester, St. John's Wood, Uckfield, and Hartwell House. Of these storms that of the 26th of June was the worst; it was described by M. J. Johnson, Esq., of Oxford Observatory, as the most violent storm of thunder and lightning ever remembered there; it began about 2·30 p.m., and lasted till about 4·30 p.m. Two college towers were struck by lightning: no life was lost. But he had heard of five persons (three children) who were thrown down by the violence of the lightning; there appears to have been two storms, one succeeding the other after an interval of about 30 minutes. Mr. Johnson remarks, "I was not here myself, but the storm has been described to me by two trustworthy persons as terrific. As far as I can make out, the storm passed over the town in a N.N.E. direction."

At Hartwell Rectory, the Rev. C. Lowndes states, that on the 26th June thunder was heard at 1·30 p.m., and at 3 p.m. there was a heavy storm with thunder and lightning; it continued stormy during the evening and night.

At Hartwell House, Mr. Horton says that on June 26th a mansion near Thame, called Thame House, about ten miles from here, was set on fire by the lightning.

At Truro, Dr. C. Barham says, "The thunder-storm on June 21st was rather severe, but more so a few miles to the northward; eleven sheep were killed by the lightning in one field, and four in a neighbouring one about ten miles to the north-east; the rain was not very heavy, and there was no hail. There was a fall of 16° of temperature between 1 and 5 p.m., and the weather has continued unsettled, with showers and squally from that time to the present (July 3)."

At Exeter, Dr. Shapter says that, for three days previously to June 26th, the atmosphere had gradually become hot and sultry, and at 4 p.m. on that day it became exceedingly oppressive. Distant thunder was then heard, and heavy rain clouds came up with a light wind from the south; at 6 p.m. the storm reached Exeter, the lightning was constant and vivid. Heavy rain fell for two hours, when the storm moderated and passed on and the wind shifted rather suddenly till 6 p.m. It reached Bridgewater at 9 p.m. The electric telegraph at the South Devon Railway was rendered useless for several hours, and the trains consequently delayed. Rain fell to the depth of 1·21 inch during the storm.

At Uckfield, C. L. Prince, Esq. says, on the 26th, at night, there was a very severe thunder-storm, and that the electric fluid struck a house in that place, and shattered a portion of the roof, burnt some clothes, &c.; but injured no one, although there were thirty persons under the roof at the time.

At Southampton, John Drew, Esq., F.R.A.S., says that rain fell to the depth of 1·96 inch on June 26th.

Thunder was heard, but lightning was not seen, on April 11 at Rose Hill (Oxford) and Saffron Walden; on the 12th at Saffron Walden and Norwich; on the 17th at Hartwell House; on the 20th and 21st at Nottingham; on May 7th at Guernsey; and the 13th at Cardington, Stone, and Aylesbury; on the 17th at Nottingham; on the 18th at Wakefield and Nottingham; on the 19th at Cardington and Nottingham; on the 21st at Exeter and Hawarden; on the 22nd at Aylesbury and Holkham; on the 23rd at Aylesbury, Norwich, Holkham, Oxford, Wakefield, and Stonyhurst; on the 25th and 26th at Hawarden; on the 27th at Guernsey, Wakefield, and Stonyhurst; on the 31st at Hartwell Rectory, Leinslade (Bucks), Cardington, Oxford, Liverpool, Stonyhurst, and Whitehaven.—On June 5th at Nottingham and Dundee; on the 6th at Stone and Nottingham; on the 9th and 11th at Stone; on the 12th at Helston; on the 16th at Stonyhurst; on the 25th at Nottingham; on the 26th at Jersey, St. John's-wood, Wakefield, and Nottingham; on the 27th at Stonyhurst; and on the 28th at Jersey.

Lightning was seen, but thunder was not heard, on April 2nd at Stone and Stonyhurst; on the 20th at Nottingham. On May 2nd at St. John's-wood. On June 5th at Nottingham; on the 26th at St. John's-wood; on the 27th at St. John's-wood and Aylesbury; on the 28th at Aylesbury and Cardington; on the 29th at Aylesbury.

The daily *horizontal movement of the air* was 110 miles in April, 96 in May, and 90 in June.[*]

Wheat in ear, at Aylesbury on June 9th; at Leinslade (Bucks) and Hawarden on the 10th; at Holkham on the 11th; at Cardington on the 12th; at Helstone, Stone, Hartwell, and Oxford on the 16th; at Nottingham on the 20th; at Leeds on the 24th.

Wheat in flower, at Jersey on June 8; at Uckfield on the 10th; at Guernsey on the 16th; at Holkham and Stonyhurst on the 20th; at Stone on the 21st; at Hawarden on the 22nd; the white at Wakefield on the 22nd, and the red in the same field on the 26th; on the 23rd at Helston, Hartwell, Leinslade, and Derby; on the 25th at Cardington; on the 26th at Nottingham; on the 28th at Rose-hill, near Oxford; on the 30th at Leeds.

Hay began to be gathered, at Hartwell and Stone on the 18th; at Hawarden and Whitehaven on the 24th; at Durham on the 27th.

The common Lilac in flower, at Jersey on April 22; at Guernsey and Helston on the 25th; at Uckfield on May 5; at Hartwell House and Wakefield on the 11th; at Aylesbury on the 12th; at Oxford on the 13th; at Stone on the 15th; at Hawarden on the 16th; at Nottingham on the 19th; at Cardington on the 20th; on the 22nd at Leeds, at Derby, and Holkham on the 23rd; at Stonyhurst on the 27th; at Durham on the 30th.

The *Cuckoo* was first heard at Uckfield on April 11; at Stone on the 12th; at Whitehaven on the 16th; at Hartwell on the 21st.

The first *Swallow* was seen at Stone on April 3; at Whitehaven on the 18th; at Nottingham on the 20th; at Hartwell Rectory on the 22nd; at Durham on the 21st of May.

The following observations of natural phenomena were taken at Highfield House, near Nottingham (being nearly in the centre of England), by Edward J. Lowe, Esq., F.R.A.S.

April 1. Willow wren arrived
.. 10. Ribes sanguineum in full glory; damson plums just in bloom
.. 11. Sand martin arrived
.. 14. Asparagus ready to cut; found nest of longtail'd titmouse
.. 16. Whiteheart cherry just in flower
.. 18. Wild cowslip in flower
.. 20. Swallow arrived; corncrake first heard
.. 21. Snowy mespulis in flower; nightingale's first song; Daphne cueorum just in flower
.. 28. Hedges in full leaf
.. 30. Some chesnut trees in nearly full leaf
May 1. Daphne japonica in full flower
.. 4. Sycamores in full flower
.. 5. Apple (Maltster) in full blossom
.. 6. Morella cherry in full blossom
.. 8. Beech in full leaf
.. 9. Swift arrived
.. 10. White broom just in flower
.. 13. Apples in full blossom; cuckoo heard
.. 16. Spotted flycatcher arrived; double gorse in full flower
.. 17. White lilac has few blossoms expanded; hawthorn do.; wheatear building a nest; rhododendron caucasicum in full bloom
.. 19. Apples generally in full blossom
.. 22. Purple lilacs in flower
.. 23. Laburnum in full flower; double blossomed cherry in flower
.. 24. Whinchat nest with eggs
May 25. Lilacs in full glory
.. 26. Pink hawthorn just in flower
.. 28. Oak nearly in leaf; hybrid rhododendron in flower
.. 29. Yellowhammer's nest with eggs; reed sparrow's do.
.. 30. Flowing ash in flower
.. 31. Lupinus polyphyllus in flower; flycatcher's nest with eggs; tree peony just in flower; lily of valley in flower
June 2. Snowball tree in flower
.. 7. Lilacs out of flower
.. 9. Woodbine in flower
.. 12. Japonica in full flower
.. 13. Syringer in flower
.. 14. Laburnums out of flower
.. 16. Rosa canina just in flower
.. 13. Wheat just showing ear.
.. 16. Leonicera publiceus just in flower; tree peony out of flower; peas ready to gather
.. 17. Rose (Mrs. Bosanquet) just in flower; elder just in bloom
.. 20. Strawberries just ripe; acacia in flower; hay, some housed to day, very little as yet cut; barley just coming in ear; wheat in full ear
.. 24. Rose (Persian yellow) in flower; kalmia latifolia var. albu in full flower
.. 26. Portugal laurel in full flower; wheat in flower
.. 31. Roses of all kinds in full glory.

The following table contains the mean quarterly values of the several subjects of meteorological investigation during the past quarter.[*]

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[*] See the *Philosophical Magazine* for August 1860, for tables of the direction of the wind.

[†] For the monthly values see the Quarterly Report of the Registrar-General.

Meteorological Table for the Quarter ending June 30th, 1850.

The observations have been reduced to mean values, and the hygrometrical results have been deduced from "Glaisher's Tables."

Names of the Places.	Mean Pressure of Air reduced to the level of the Sea.	Mean Temperature of the Air.	Highest reading of the Thermometer.	Lowest reading of the Thermometer.	Mean Daily Range of Temperature.	Mean Monthly Range of Temperature.	Range of Temperature in the Quarter.	Mean Temperature of the Dew-Point.	Wind. Strength.	Wind. Direction.	Mean Amount of Cloud.	Rain. Number of Days on which it fell.	Rain. Amount Collected.	Mean weight of Vapour in a cubic foot of Air	Mean additional weight required to saturate a cubic foot of Air.	Mean degree of Humidity.	Mean whole amount of Water in a Vertical Column of Atmosphere	Mean Weight of a cubic foot of Air.	Height of Cistern of Barometer above the Level of the Sea.	Names of the Observers.
	in.	°	°	°	°	°	°	°					in.	gr.	gr.		in.	grs.	ft.	
Guernsey	29·575	52.9	75·0	41·0	10·2	22·8	34·0	48·3	1·5	W.	4·5	46	7·2	4·1	0·6	0·864	4·9	535	129	Dr. Hoskins, F.R.S.
Helston	29·455	52·2	86·0	32·0	16·1	35·3	54·0	46·6	1 6	S.W.&N.W.	5·4	34	8·4	3·9	1·4	0·747	5·0	531	106	M. P. Moyle, esq.
Falmouth	..	52·0	84·0	34·0	16·4	35·0	50·0	..	1 4	Var.	6·5	41	8·7	..	..	..	..	..	120	L. Squire, esq.
Torquay	..	54·1	75 0	40·0	11·6	26·0	35 0	46·8	1·4	W. & N.E.	..	42	8·8	4·5	1·1	0·758	..	535	..	E. Vivian, esq.
Truro	..	52·6	83·0	28·0	15·6	37·8	55·0	46 6	1·1	N. & S.W.	6·0	38	7·7	3·8	1·0	0·800	4 7	536	..	Dr. Barham
Exeter	29·542	53·8	86·2	31 6	19·8	40·6	54·6	47·5	1·8	Var.	3·7	43	9·0	4·0	0·9	0·813	4·7	533	140	Dr. Shapter
Chichester	..	52·3	81·0	33·0	16·6	37·3	48 0	..	..	Var.	..	..	7·7	..	..	..	..	..	..	W. Hills, esq.
Uckfield	29·578	53·8	87·0	25·0	21·5	48·3	62·0	47·7	..	S.W.	..	38	9.1	3·7	1·4	0·704	4·5	532	180	C. L. Prince, esq.
Southampton	29·574	53·5	82·0	30·3	..	38·0	51·7	49·3	0·4	..	6·0	41	10·1	4·2	1·1	0·799	5·0	537	55	John Drew, esq., F.R.A.S.
Royal Observatory, Greenwich	29·598	53·5	85·1	31 7	20·3	42·5	53·4	45 1	..	S.W.	..	45	5·6	3·9	1·2	0 754	4·4	532	159	The Astronomer Royal
Maiden Stone Hill, Greenwich	29·532	52·7	81·3	30·5	17·5	38·5	50·8	48·5	..	Var.	6·6	43	5·6	4·1	0·8	0·847	5·0	533	107	Mr. William Ellis
St. John's Wood	29·591	53·0	81·7	32·0	18·1	40·5	49·7	42·4	1·6	..	6·4	44	5·7	3 3	1·4	0·712	4·0	533	150	George Leach, esq.
Chiswell-street, London	29·595	55·6	77·0	40 0	12·1	29·3	37 0	46·9	..	..	..	40	5·6	3·8	1·3	0·734	4·7	530	170	David Slate, esq.
Aylesbury	29 663	53·2	86·0	30·0	21·0	44·0	56·0	43·8	0 6	S. & W.	..	41	5·1	3·5	1·4	0·719	4·2	530	284	Thomas Dell, esq.
Stone Observatory	29 563	51·9	82·5	29·9	19 5	41·8	52·6	44·4	0 9	S.W. & N.E.	..	43	5·4	3 5	1·0	0 777	4·3	529	320	Rev. J. B. Reade, F.R.S.
Hartwell (near Aylesbury)	29·558	52·6	85·0	29·0	21·4	43·1	56·0	45·3	1·2	S.W. & N.E.	7·0	47	4 0	3·7	1·1	0·778	4·4	532	250	Dr. Lee, F.R.S.
Hartwell Rectory	29 570	51 9	84·2	31·0	19·2	40·6	53·2	44·1	0·8	S.W.&N.W.	5·8	46	3·9	3·5	1·1	0·762	4·4	530	290	Rev. C. Lowndes, F.R.A.S.
Leinslade (Bucks)	..	52·9	85·0	32·0	18·7	40·7	53·0	..	..	N.E.	..	47	4·8	..	..	..	..	..	318	John Osborn, esq., Junr.
Radcliffe Observatory, Oxford	29·577	52·0	..	..	..	..	..	47·3	2·1	N.E. & S.W.	7·3	40	6 3	3·9	0·7	0·850	4·7	531	210	M.J.Johnson, esq., F.R.A.S.
Rose Hill (near Oxford)	29·587	52 5	86·0	30·9	19·[illegible]	41·9	55·1	47·3	2·0	S.W.	7·5	45	..	4·0	1·0	0·834	4·9	530	270	Rev.T.Slatter,esq.,F.R.A.S.
Cardington	29·567	52·5	83·0	30·8	19·2	41·6	52 2	45 6	1 2	N.E. & S.W.	7·0	39	4·9	3·7	1·0	0·778	4·3	534	100	S.C.Whitbread,esq.F.R.A.S.
Norwich	29·518	51·2	80·0	30·0	16·3	38 6	50 0	45·9	..	S. & S.W.	7·0	30	5·2	3·7	0·8	0·840	4·5	536	23	W. Brooke, esq., F.R.A.S.
Holkham	29 583	51·8	81·2	30 3	15·7	42·0	50·9	43·9	1·2	N.E.	6·3	36	4 1	3 5	1·0	0·785	4 2	537	39	The Earl of Leicester
Nottingham	29 518	52·4	87·2	29 8	20 8	45·0	57·4	45·5	0 6	N.E.	7·0	50	4·9	3·7	1·0	0 789	4·5	532	103	E. J. Lowe, esq.
Derby	..	50·9	80·0	29·0	17 8	37·7	51·0	46·7	..	..	..	51	5 2	3·8	0·7	0 848	4·6	535	..	John Davis, esq.
Manchester	29·569	52·6	..	..	..	..	..	45·8	..	S.W.	6·6	46	5·6	3·8	1·0	0·790	4·6	533	144	G. Vernon, esq.
Hawarden	29·560	51·1	75·5	32·4	18·5	33·5	43·1	43·7	2·0	S.	7·0	38	5·1	3 5	1·0	0·782	2·9	531	260	Dr. Moffatt, F.R.A.S.
Liverpool	29·536	52·9	74·7	36·7	10·6	26·7	38.0	46·7	1·2	Var.	6·3	38	4 2	3·9	0·9	0·819	4·7	536	37	John Hartnup,esq.,F.R.A.S.
Wakefield	29·550	50·9	84 0	26·0	20 0	42·7	58·0	44 2	1·9	Var.	7·2	55	5·0	3·6	1 0	0·744	4 2	535	115	W. R. Milner, esq.
Leeds	29·597	50·5	80·0	30·0	17·6	39 0	50·0	44·8	1·4	..	5 0	46	5·1	3·5	0·8	0·820	4·3	531	125	C. Charnock, esq.
Stonyhurst	29 578	49·6	79·0	27·9	16·7	36·9	51·1	42 3	1 3	W.	7·7	47	9·5	3·5	0·6	0·799	4 3	530	381	Rev. A. Weld, F.R.A.S.
York	29·562	50·4	77 0	31·0	15 3	33·7	46·0	44·4	..	N.E. & S.W.	..	42	4·5	3·6	0·9	0·798	4·3	536	50	John Ford, esq.
Whitehaven	29 531	50·3	78·5	32·5	12·4	33·2	46·0	44·8	1·9	S.W.	..	48	6·4	3·6	0·6	0·860	4·3	537	90	J. F. Miller, esq., F.R.S.
Durham	29 424	49·1	76·8	27·1	14·1	39 8	49·7	44·8	0·9	Var.	6·6	46	4·8	3·6	0·7	0·839	4.4	531	340	R. C. Carrington, esq.
Newcastle	..	50·6	80·0	32·0	12 9	32 3	48·0	44·4	..	S.E. & N.W.	..	33	..	3·6	0·9	0·804	4 3	536	..	G. Murns, esq.
North Shields	29·584	48·1	78·7	33·0	10·4	29·5	40·7	44·6	..	Var.	6·0	61	5·5	3·6	0·4	0 934	4·3	540	90	R. Spence, esq.
Glasgow	..	49·7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Dr. R. D. Thomson

The mean of the numbers in the first column is 29·561 inches, and it represents that portion of the reading of the barometer due to the pressure of air; the remaining portion, or that due to the pressure of water, is 0·322 inches: the sum of those two numbers is 29·874 inches, and it represents the mean reading of the barometer for the quarter ending June 30, 1850.—By taking the mean of the numbers in the preceding Table for those places situated between different parallels of latitude, the following Table was formed.

Quarterly Meteorological Table for different Parallels of Latitude.

Parallels of Latitude, &c.	Mean Temperature of the Air.	Mean of Highest Reading of the Thermometer.	Mean of Lowest Reading of the Thermometer.	Average Daily Range of Temperature.	Average Monthly Range of Temperature.	Average Quarterly Range of Temperature.	Mean Temperature of the Dew-Point.	Mean amount of Cloud.	Rain. Average Number of Days.	Rain. Average Fall.	Mean Weight of Vapour in a cubic foot of Air.	Mean Additional Weight required to saturate a cubic foot of Air.	Mean degree of Humidity.	Mean whole amount of Water in a vertical Column of Atmosphere.	Mean Weight of a cubic foot of Air.	Mean Height above the Sea.
	°	°	°	°	°	°	°			in.	gr.	gr.		in.	gr.	ft.
In the Counties of Cornwall and Devonshire	53·5	81·5	34·4	13·3	32·8	47·1	47 6	5·2	40	8·3	4·1	1·0	·796	4·8	534	122
South of Latitudes 52°	53·0	83·4	31·2	18·7	40·2	52·2	46·0	6·7	43	6·0	3·8	1·1	·773	4·5	532	230
Between the Latitudes of 52° and 53°	52·0	82 3	30·0	17·9	41·0	52·3	45 5	6·8	41	4·8	3·7	0·9	·808	4·5	535	66
Between the Latitudes of 53° and 54°	51·0	79·3	29·5	16·6	37·2	49·6	44·1	6·7	46	5·8	3·6	0·9	·789	4·1	533	179
Liverpool and Whitehaven	51·6	76·6	34·6	11·5	30·0	42 0	45·7	6·3	40	5·3	3·8	0·8	·840	4·5	536	27
Durham, North Shields, and Newcastle	49·3	76·8	30·7	12·5	33·9	46·1	44·6	6·3	47	5·2	3·6	0·7	·859	4·3	536	340
Glasgow	49·7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

The highest reading of the thermometer in air was 87° at Uckfield and Nottingham; and the lowest readings were 25° at Uckfield, and 26° at Wakefield. The extreme range of temperature during the quarter, in England, was therefore about 60°

The least daily ranges of temperature took place at Guernsey, Liverpool, and North Shields—their mean value was 10·4°; and the greatest occurred at Uckfield, Aylesbury, and Hartwell, and their mean value was 21·3°.

The least monthly ranges of temperature occurred at Guernsey, Torquay, and Liverpool—their mean value was 25·1°; the greatest took place at Uckfield, Aylesbury, and Nottingham—their mean value was 45·8°.

Rain fell on the least number of days, at Helston, Holkham, and Norwich—the average number at these places was 33. It fell on the greatest number of days at North Shields, Wakefield, and Derby—the average number at these places was 56. The places at which the largest falls took place were Southampton, Stonyhurst, and Exeter; the average amount at these places was 9·5 inches. The smallest falls occurred at Hartwell, Holkham, and Liverpool, and their average was 4 inches.

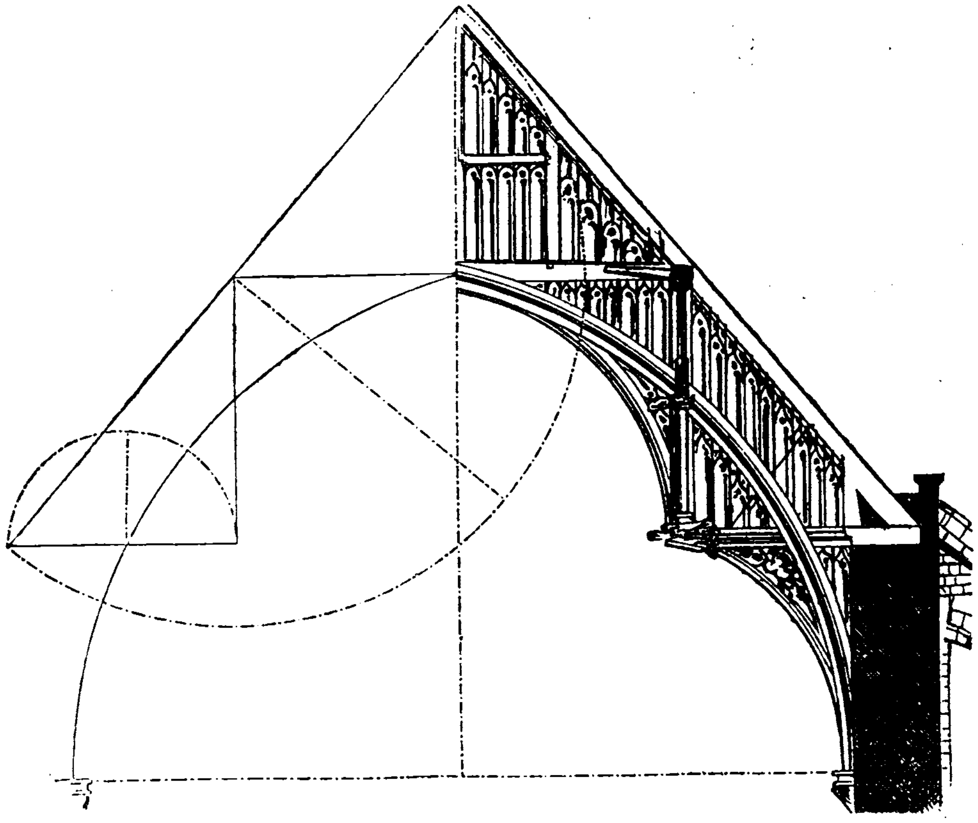
OPEN TIMBER ROOFS.

Glances at the Structural Principle of the Roof of Westminster Hall, and the indications of a disused Method of Supporting Roofs, afforded by existing evidences in this Country, and analogous Continental Examples. By Thomas Morris, Esq., Architect. (Paper read at the Royal Institute of British Architects, June 24th.)

Having a few years ago, in a paper to which you did me the honour to listen, treated on mediæval wooden roofs, and endeavoured to exemplify the structural principle of that of Westminster Hall, I have not read with indifference some recently published adverse opinions; and the grateful sense I entertain of your indulgence on former occasions, leads me, though with much diffidence, to bring a few remarks, thus directly, under the notice of gentlemen so highly qualified to exercise a judgment on the subject.

As the opinions alluded to arose from the review of a popular and very useful collection of open timber church roofs, it may be at once stated, that these are so inferior in size and scientific development to the finer domestic specimens (the boldest ecclesiastical example scarcely exceeding thirty feet, while Westminster Hall is sixty-eight feet wide), that I regard the volume in question, and its authors, as perfectly unobnoxious to remark, in a critical consideration of the matter.

Those, indeed, who, from a conviction of the highly suitable and effective character of the open wooden roof for sacred, as well as civil edifices, would wish to revive and extend its application at the present time on true principles, will, I think, prosecute their object, with the fairest aim at excellence, by the diligent examination of those stupendous examples devoted to secular uses, in which the resources of art are most fully displayed. They will thus be best prepared to impart intrinsic merit to ecclesiastical works, too often left to rest their claim for respect on embellishments received from the carver or the colourist.



Had we examples of this latter kind only, notwithstanding the poetically typical significance and elaboration of detail possessed by many, the charge against our ancestors of a total failure to assimilate open roofs with the compressible architecture, or that called Gothic, might have remained uncontroverted; but, fortunately, we have instances of the most successful treatment, and of such none are more worthy of admiration, both for unapproached magnitude and ability of contrivance, than that of Westminster Hall. A recognition of the true system of its construction is calculated to be highly conducive to the progressive excellence of such works, and I shall esteem it a great satisfaction to be, however humbly, useful in so desirable a result.

Two authorities condemnatory of this roof have been brought more prominently forward—namely, Mr. Bartholomew and Dr. Robison. The first of these says, "No work on the earth perhaps exhibits more excellence of workmanship, and perhaps none shows more assiduity and skill of an inferior kind to obviate the thrusting power of the roof, but the whole being constructed on false and unscientific principles, it is in vain that this want of science is concealed by intricacy of framing and excellence of workmanship." If I am not mistaken, the writer here quoted has been entirely misled by the intricacy of the merely subordinate panelling or tracery; but as this will presently be more fully entered into, I shall proceed to Dr. Robison's view of the case.

"Westminster Hall," he says, "exhibits a specimen of the false taste of the Norman roofs. It contains the essential parts indeed, very properly disposed: but they are hidden, or intentionally covered, with what is conceived to be ornamental, and this is an imitation of stone arches, crammed in between slender pillars, which hang down from the principal frames, trusses, or rafters. In a pure Norman roof, such as Turnaway Hall, the essential parts are exhibited as things understood, and therefore relished."

It is surprising that a paragraph, betraying such extreme ignorance of dates and architectural characteristics, should have emanated from a writer of the Doctor's standing, even in the last century, and yet more astonishing that it should be put forward by a professional critic of the present day. It clearly shows, however, the impression that the internal parts of the truss really depend from the main rafters. Excepting the lower part of the walls, the Norman hall of William Rufus was re-built three centuries afterwards by Richard the Second, who, on its completion, in the year 1399, solemnised Christmas by a characteristically splendid feast; and every lineament of the roof, so far from partaking of the Norman manner, proclaims its origin to have been late in the fourteenth century.

The error in thus following Dr. Robison might alone warrant a doubt whether the concealments of which the writer who quotes him speaks actually exist, and whether his assertion, that "constructive principles, if true, must be anti-Gothic; that to make open roofs beautiful and truthful, all Gothic ideas must be relinquished, &c.," have received from himself the reflection befitting their unqualified expression. With respect to the remaining portions of the critique alluded to, I may say, with the editor of the journal in which it appeared, "that his arguments have not convinced ourselves;" and then I will proceed to bring under notice that key to the construction of this truly wonderful example of carpentry which I ventured to advert to in this Institute six years ago. It was, however, mentioned as one among a series, and the prominence that will be imparted to it by thus receiving your attention in a detached form will, no doubt, secure the removal of any error it may contain, and the candid admission of any merit it may possess.

My observations went to show that the arch was not merely a very grand ornamental feature, but that it was absolutely the essential principle and weight-sustaining medium of the truss; and should this hypothesis prove correct, the propriety of the Gothic, or the compressible system of design in carpentry must, I conceive, be admitted.

Commencing, then, with the great arch rib, which in its section is upwards of two feet each way, and spans the width of the hall, we find, that dividing the curve from the springing to the apex into three parts, the first of such divisions gives a point in the rib at which it is intersected by a massive horizontal beam of nearly equal dimensions with itself. This horizontal timber, called the hammer beam, extends outwards to the foot of the rafter, and is continued in the opposite or inward direction to the same extent, so that if secured on a central pivot, this timber might be acted upon as a scale-beam or lever of the first order, and if loaded equally at both ends would remain in its horizontal position, while the entire weight would be concentrated at the pivot and thrown upon the supporting arch. If, taking the hammer beam as a base, we draw a perpendicular line from the inner extremity, it will be found to cut the rafter, or surface of the roof, just midway between the foot and the ridge, and taking this rafter or surface line as the hypotenuse, a triangle will be completed.

This triangle will be found to have an exact counterpart in the upper half of the roof; but as the weight is proportionate to the superficial area, it is only necessary to explain that this area is divided longitudinally into two equal parts that under this divisional line a purlin exists, upon which is collected the weight of the upper half of the roof, and this weight is transmitted, by a vertical post, to the inner end of the hammer beam. The lower half of the roof discharges, in like manner, its weight on the outer end of the same timber, and the equipoise is thus rendered perfect.

If the accuracy of this much be conceded, I think but little remains for discussion. The fitness of the skeleton for its intended purpose once seen and admitted—the graceful adaptation of the tracery, and minor arrangements for supporting the slighter parts by aid from the stronger will be manifest, and especially so when it is recollected that gravitation is not the only force to be resisted, but that the powerful action of the wind, on so large a plane, has also to be largely provided against. In tracing the history of these roofs, I have formed the opinion that their type is found in the stone gablets, or principals, employed in early halls, of which Conway Castle affords good examples, and a specimen also exists in the Manor House at Ightham, in Kent.

Professor Willis has remarked—"A small chapel at Capo di Bove, about a mile outside Porta S. Sebastiano, Rome, figured by Agincourt, has the roof entirely sustained by a series of pointed arches, resting on corbels, and entirely superseding the usual trusses." I have not met with this illustration, but by the kindness of Mr. Railton, I can supply its place by the drawing of a chancel, in which he has carried the principle into effect. The more ancient employment of such gablets may be further referred to in the aisles of Hartlepool Church, Durham, where they exist in a perfect state; and of St. Peter's, Northampton, where the remaining portions clearly indicated (at the time of my visit a few years since) their original use. The nave of St. Peter's Church, I am inclined to think, had its roof supported by a series of such gablets, above the alternate piers. The Church of San Miniato, without the walls of Florence, has precisely this arrangement, except that the gablet occurs over every third pier only; but in other respects the quatrefoil plan of the pier, and the appropriation of two of the group of shafts to the support of the nave arches (one at the back for the gablet across the aisle, and the fourth in the front, which is carried up on the face of the clerestory, for supporting the arch and gable over the nave) are identical in the two churches.

Speaking of San Miniato, Mr. Galley Knight observes—"Large arches are thrown at intervals over the nave, connected with smaller arches, which are thrown over the aisles, at once assisting to support the roof, banding the whole fabric together, and giving it additional strength. When these arches occur, the pillars are exchanged for compound piers, one shaft of which is carried up to meet the arch above."

At San Zeno, Verona (a Romanesque edifice, begun in 1138, and finished in 1178) every alternate pier is a massive collection of shafts, with arches crossing the aisles and nave, as in the above instances. So striking indeed is the resemblance in these buildings to many of our own Norman churches, where we find shafts carried up with no reference to the present roofs, and yet well adapted to the support of such gablets as I have been describing, that there seems good reason to conclude that such features were at one time very general in this country, as well as abroad, and the question addresses itself to the attention of those entrusted with the restoration of our more ancient churches.

Previous to the date of the Westminster roof, timber arches had been applied in a form consonant to the general characteristics of their date, as at Nursted Court, near Gravesend, and other places; whether the hall of Rufus was entirely covered by wooden framing, or had stone supports, the construction in wood of such a gablet as we have been considering, was the task proposed to himself, and, in my humble opinion, nobly performed by the architect of Richard the Second. Of those indeed who, to prove the falsity of its principle, refer to the distortion it has sustained in four centuries-and-a-half, it may be fairly inquired, whether the many failures in masonry warrant the denial of truth in the theory of the arch altogether. The term "foliated" has been ably advocated as applicable to the later wooden roofs, but in examples antecedent to the introduction of foliations as a common architectural feature, the roofs were, of course, without that characteristic; and in modern works where cusps are excluded, as in lancet buildings, they are, I presume, still generally and properly omitted. Such unfoliated roofs "possess," it has been said, "the merit of giving a grand and church-like, though simple effect, without doing violence to the genius of its material." They certainly embody, in an eminent degree, the principle of rendering elegant the essential constructive elements, and of avoiding adventitious parts for ornament alone.

In concluding these remarks, I will advert for a moment only to the unfairness and futility of instituting comparisons between open wooden roofs and stone groinings, unless they were equally suited to our means, and depended for adoption entirely on choice. I am far from insensible to the charm of "the fretted vault," but where is an example as capacious as Westminster Hall, doubling, as it does, the breadth of our widest cathedral nave? When wood, applied to the purpose of groining, is painted, and made to represent stone, a deception is clearly practised; but, regarding the arched ramifications of a natural grove as the type followed in ribbed vaultings, there would seem little impropriety in representing the "fair branches and shadowy shroud" of the cedar fairly and ostensibly in timber. The subterfuges witnessed in the wooden groining over parts of St. Alban's Abbey, York Minster, and other buildings, are, doubtless, owing to the ponderosity of stone. The sacrifice of internal height, which many of our finest edifices have sustained from the introduction of stone groining (and which would bequite destructive of effect in buildings of wide proportion), lays them open to the severe remark upon the splendid outer dome of St. Paul's, of being "a mere imposing show, constructed at a vast expense, without any legitimate reason;" for it need not be mentioned, that the groined ceiling never supersedes the ordinary roof, and between the two there often exists a chamber of considerable height, not only for the purpose of increasing the weight of the walls, and their ability to resist the thrust of the groin, but also to admit of building the latter under cover. The cost of the centring alone for a stone ceiling would, probably, pay for the decoration of an open roof; and the value of fair groining, if taken at fifty pounds a square, which experience enables me to state as a proximate sum, would place it quite beyond general application. While economy therefore confines us almost exclusively to the open form of roof, it is gratifying to experience the conviction, that it is truthful in principle, and, when artistically treated, capable of displaying, in the fullest and most graceful manner, the entire capacity of the building it covers.

Remarks.—Mr. Donaldson thought that Mr. Morris had confined his remarks somewhat too exclusively to the peculiarities of construction in the roof of Westminster Hall. He had not, in his opinion, sufficiently alluded to the numerous other examples of a similar kind existing in this country. It should be borne in mind, that in the roof of Westminster School, of which a drawing was exhibited, it had been found necessary to introduce cross tie-rods to connect the opposite hammer beams. It was a remarkable fact, that the flying buttresses of Westminster Hall are not placed exactly opposite the principals of the roof, and that a straight joint is to be seen between them and the wall: this would tend to prove that the stability of the roof is not dependent on them, and that they had been probably added at a late period, when the walls had evinced signs of weakness.

Mr. **Morris** replied, that the object of his paper had been to show that the arch-ribs of Westminster Hall are not mere ornamental portions of the structure, but that the weight of either side of the roof is brought to bear upon two of the strongest points of each rib. At Eltham the same principle was carried out, some eighty years later than in the present case.

Mr. T. T. **Bury** (Fellow), mentioned, that in the clerestory roof of St. Mary's, at Bury St. Edmund's, the hammer-beam construction is introduced alternately with the single arch-rib, and produces a varied and good effect.

Mr. **Bellamy** (Fellow), thought that no one could look at the roof of Westminster Hall without feeling assured of its stability; and he was astonished, that after it had stood the test of time during four centuries-and-a-half, any one should venture, not only to decry its beauty, but actually to call in question its principles of construction.

Mr. C. H. **Smith** stated, that upon a close inspection of this roof, he had ascertained that the foot of the arch-rib did not rest upon the projecting portion of the moulded stone corbel, but that an actual space existed between them; and he had been informed by a competent authority, that this is the case with many similar roofs.

Mr. **Fowler**, V.P., said, that he also had an opportunity of closely inspecting the construction of the roof of Westminster Hall at the time of the erection of the lantern, and of the general repair some thirty years ago, and he had observed the expedients adopted to secure the roof, by means of bolts and ties, which compensated for the decay of the pins and tenons of the framing, but were not required from any defect in the principles of the construction. With respect to the paper which had been read, he gave the author great credit for his ingenious explanation of the principle on which this roof was constructed—viz., that of equipoising different portions, and eventually bringing their whole weight to bear upon the points best adapted to receive it. Mr. Smith's observations respecting the corbels did not, in his opinion, tend to disprove the theory advanced by Mr. Morris, but rather showed the prudence of those who constructed the roof; it would certainly have been very injudicious to allow the feet of the ribs to impinge upon the extreme ends of the corbels, weakened as they were, to some extent, by the mouldings. The ribs were, doubtless, continued into the solid of the wall. He was glad to see that this mode of construction was not only admired, but had actually been carried out in some of our modern buildings.

Mr. **Tite** (Fellow), thought that all the theoretical objections to the principle of construction of such roofs as Westminster Hall were most satisfactorily answered, by the mere fact of their having stood the test of centuries; and he thought we might be well satisfied, could we assure ourselves that the roofs erected in our time would be in as good a state of preservation 450 years hence as that now covering Westminster Hall. He also observed, that all tie-beam roofs are liable to objection, on account of the shrinking and deflection of the timbers.

Mr. **Penrose** (Fellow), thought that the arched form of the rib had more to do with the appearance than with the stability of the roof. He remarked, that in the roof of Westminster Hall timbers acting as struts had been introduced between the main ribs and the principal rafters; and he was inclined to consider that the real advantage of the ribs consisted in their acting also as struts, and, at the same time, binding the whole frame-work together. It should be remembered that there were many roofs formed on the tie-beam principle, which were well worthy of commendation—as, for instance, that of St. Nicholas, at Lynn, in Norfolk, and many others in Somersetshire; and it must not be forgotten, that these roofs can be executed at a far less outlay than those constructed on the arch principle.

Mr. G. G. **Scott** (Fellow), considered that the curved, or arched rib, was not useless. Its object was not so much to bear any portion of the weight of the roof as to prevent it spreading outwards. This was done also, to some extent, at King's College. In a roof of 66 feet span, without a tie-beam, like that of Westminster Hall, we had no right to complain of the existence of buttresses; but, in his opinion, they were used rather as a precaution, than from necessity. It must be remembered that the walls were 300 years older than the roof; and it was very probable that the buttresses were erected with the view of counterbalancing any weakness that might have been produced by such a lapse of time. Had the walls been new, buttresses, in such an erection, could not be condemned.

The **Chairman** thought it was worthy of remark, that the buttresses are so constructed as not to give their resistance at the point where the greatest lateral thrust is exerted—viz., at the level of the stone corbels.

Mr. G. G. **Scott** drew attention to the roof of a remarkable ruin at Mayford, in Sussex, which was of 40 feet span, and had stone principals, or gablets; the walls were of moderate thickness; and, although the hall had been in ruins 300 years, these stone principals were quite sound.

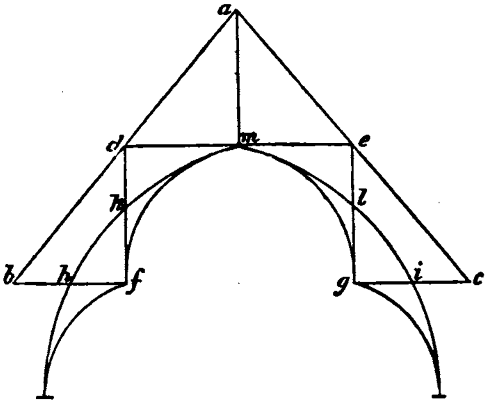
The **Chairman**.—The roof was counterbalanced by buttresses.

Mr. **Scott**.—Yes; but the buttresses are in ruins, while the arches or principals are yet sound.

The vote of thanks to Mr. **Morris** was then put and carried.

TO THE EDITOR OF THE C.E. AND A. JOURNAL.

Sir—In the paper read by Mr. Morris at the Institute, on the structural principles of the Roof of Westminster Hall, I have noticed what I consider to be an error in the principles of equilibration that he assigns to that structure, and on which I have a few remarks to make. I agree with Mr. Morris that the great arch ribs are not merely ornamental additions to, but principal supports of the roof; at the same time I must differ from him as to the system of equilibrium that he puts forward. If I understand Mr. Morris rightly, he says that the weight of the upper part of the roof is transmitted by means of the posts to the inner ends of the hammer-beams, which form levers, being balanced at their centres on the lower part of the arch ribs. Now, if the posts do not rest on the arch ribs, at the points *k*, *l*, this assumption is perfectly correct. The upper part of the roof being prevented by the collar-beam from spreading, may be considered as resting on the inner ends of the hammer-beams, by means of the posts *d*, *f*, *e*, *g*, and pressing vertically with half its weight on each. Mr. Morris then says: "The lower half of the roof discharges in like manner its weight on the outer end of the same timber, and the equipoise is thus rendered perfect." Now, to this I demur. The weight of the lower part of the roof *d*, *b*, *f*, will act vertically, not at the outer end *b*, of the hammer-beam, but in the vertical line drawn through its own centre of gravity; and if the great arch rib intersect the centre of the hammer-beam, then at the point of intersection. (This is speaking of the roof *covering* only, without reference to the weight of the frame; if this be considered as well, the vertical action of the lower half of the roof *d*, *b*, *f*, will be inside the point *h*, in consequence of the greater weight of the post *d*, *f*, and the framing on that side of the point.) The lower portions of the roof *d*, *b*, *f*, *e*, *g*, *c*, will then each be in equilibrio, or will balance themselves on the points *h*, *i*, of the great arch rib: this, I think, is plainly evident on inspecting the diagram. The frame *b*, *d*, *f*, with its proportional weights of covering, would plainly not keep itself in equilibrio if the point *h*, were nearer the wall, but would undoubtedly turn over on this point, and fall inwards. It is therefore impossible that the lower portions of the roof, only keeping themselves in equilibrio, can also balance the additional



weight of the upper portion of the roof resting on the posts at the points *d*, *e*. It is consequently manifest that there will be a very considerable vertical pressure on the posts *d*, *f*, *e*, *g*, unsupported by any counterpoise at the outer ends of the hammer-beams, and tending to upset the frames *d*, *b*, *f*, *e*, *g*, *c*, inwards, by turning them on the points *h*, *i*, as centres; and this would undoubtedly be the result, unless this force were otherwise counteracted. Now, this pressure, I conceive, is carried by the great arch rib at the points *k*, *l*, where the posts intersect it; and it thus affords five principal points of support to the weight of the roof—one at the centre of each hammer-beam, one at each post, and one at its apex *m*, at the collar-beam under the king post, which I conclude in this case fulfils the duty, not of a suspending tie, but really of a post. The lower arches of foliation will also assist in sustaining this weight. The pressure thus thrown on the arch ribs is discharged at their feet on the wall; and their rise being so high in proportion to their span, they probably exert a comparatively small side pressure against the wall. On the supposition of the upper part of the arch rib not receiving the pressure of the posts *d*, *k*, *e*, *l*, this pressure would of course be transmitted to the inner ends of the hammer-beams. We should then have it acting vertically, and resolving itself into a horizontal compressing force against the collar-beam at the points *d*, *e*, and an oblique force against the points *h*, *i*, of the arch ribs. In this case the direction of this pressure will be very nearly a tangent to the rib at the points *h*, *i*, and will be transmitted by the arch rib to the wall. As the wall is of considerable thickness, the direction of this pressure probably does not pass outside, but reaches the foundation within the thickness of the wall. The wall has also the weight of its upper portion above the springing of the ribs to assist it. The oblique pressure at *h*, *i*, certainly tends to force the arch ribs outwards, turning them on their springing as centres; but against this is opposed the weight of the rib itself, and also that of the arch of foliation, which acts in the opposite direction.—Offering these remarks to your notice, if you think them worth a place in your journal, I am, &c.,

July 11*th*, 1850. J. A. Davies.

LIGHTHOUSE IN THE SKERKI CHANNEL.

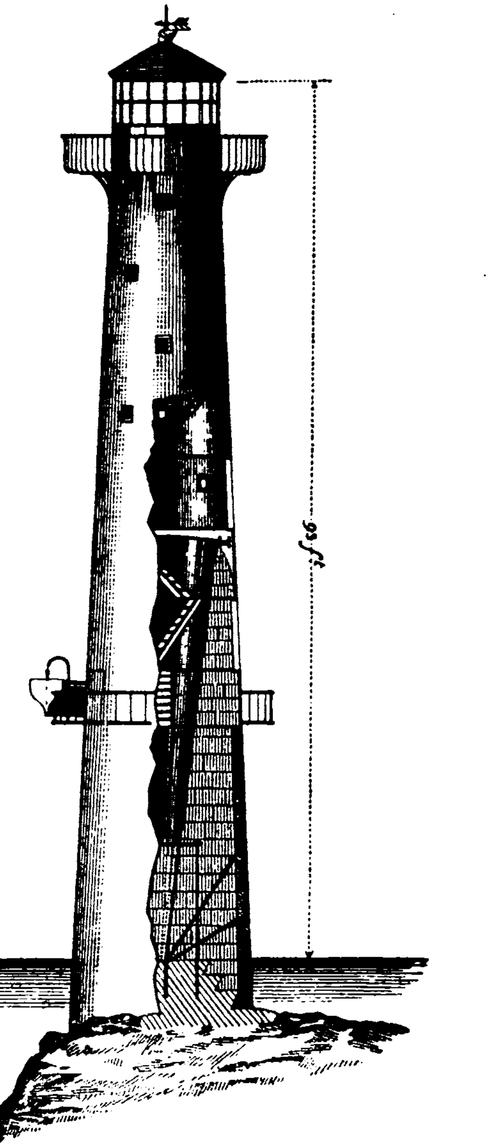
We extract the following description from a very able report by Mr. Alexander Gordon:—

"Admiral Sir Francis Beaufort suggested to me the importance of a lighthouse in the Skerki Channel, for Keith's Reef. I am now able to assert confidently, that a lighthouse can be erected on Keith's Reef, showing a light of the greatest power 100 feet or more above the sea, capable of containing stores, provisions, and water for four men, or even more, for six months, and at an expense not exceeding 17,000*l*. The rocks are compact limestone, in extent nearly half-a-mile long, and one-third of a mile broad, with a small space of about six feet square, even with the water's edge.

"The sketch is partly an elevation and partly a section of such a lighthouse as I would propose for Keith's Reef, to show a light of the most powerful character at the height of 93 feet above the water level, and the tower sufficiently spacious to contain even six men (if such should be required by stress of weather) for six months, and all necessary lighthouse stores, provisions, and water, with ample space for exercise, and for live stock.

"A strong wrought-iron bar should be at once jumped into the centre of the area of the peak, and immediately succeeded by other wrought-iron bars, on which to form a crow's nest, or an open platform; from this the surface and edges of the rock could be cleaned of the large quantity of sea-weed now upon it, and a small crane would enable us to have the edges of this rock trimmed and undercut, and a circular seat rudely prepared about six feet under water. It may not, however, be necessary to go to such a depth. A few sections of this seat will enable us to cast lead slabs weighing a ton and a-half or two tons, such as can be dovetailed into each other, and fastened together with lead joggles and dowels driven in hard, and the whole of the seams closely chinced or caulked with lead. This wall of lead will then be carried up about 15 inches thick, with the seams all chinced together below and above the water line, so as to prevent percolation of water. This lead wall, where above water, will have its seams all run together with a powerful blow-pipe. We may even manage to cast the upper portion of the lead wall upon the lower part.

"The original iron rods will now be at their upper ends worked into the inner and dry side of the lead wall, forming bond as we proceed. At the extreme base of the tower the water will now be shut out by warm gutta percha, and then by hydraulic cement. Lead will then be run in to make the base perfect; a core of masonry perfectly bonded together is to occupy a great part of the interior. The fixed crane post may then be built in, and thus be converted into bond and load; even if it should in some degree oxidise, the rust will do good rather than harm.



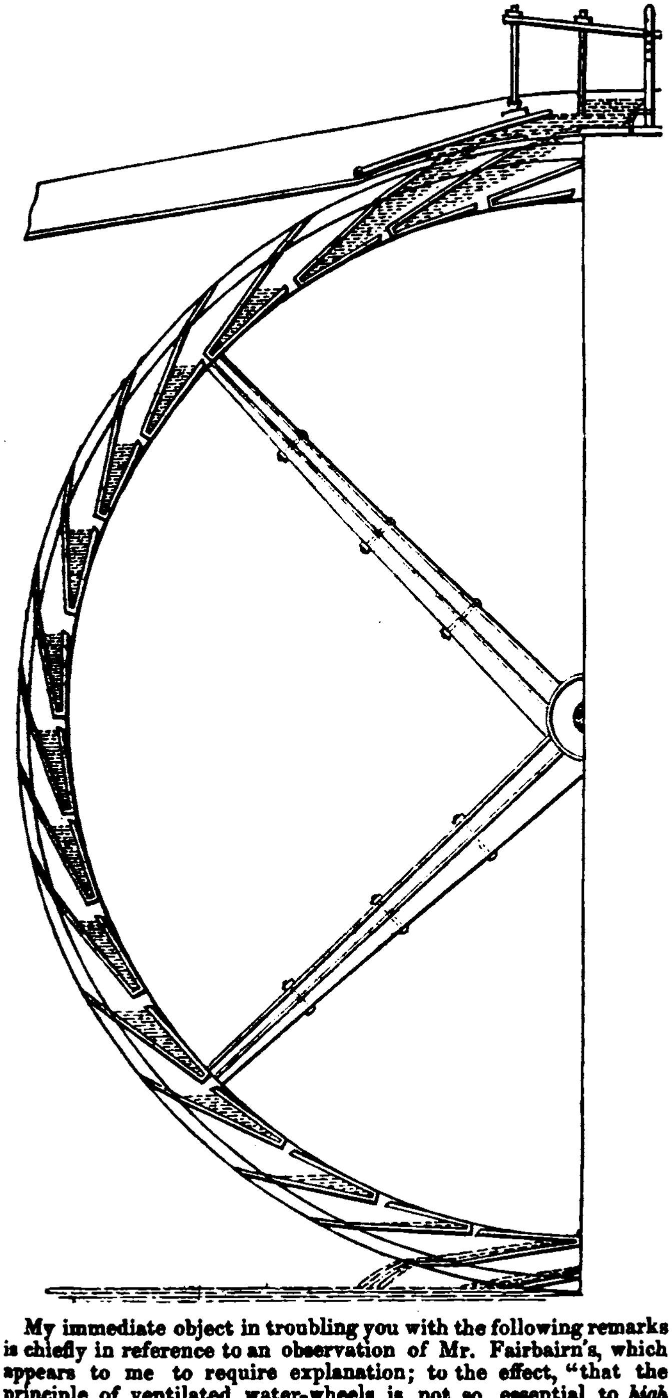
"Lead is no doubt a costly article as estimated below, but its durability in salt water; the facilities which it affords for making perfect bond; its inertia; and its not being susceptible of vibration, point it out as the best material under the circumstances.

"The lead walls are to be carried up about 24 feet above the water-line, and upon them and the core of masonry (the latter in many places bonded together with lead), there will be a superstructure of cast-iron bonded together with wrought-iron floors and fastened down to the rock by many very strong wrought-iron ties; which latter will not (where there is moisture) be allowed to come in contact with the lead. The junction of the iron shell and the lead wall must have special attention. In the event of oxidation of the iron to any considerable extent, such plates can be removed; and if the oxidation be small, we can repair the damage by scraping away the oxidised iron and running in more lead in its place. The superstructure would be much the same as that of my other lighthouses. Its cost may be estimated at 17,000*l*.

"Alexander Gordon."

OVERSHOT WATER-WHEEL.

Sir—A reader and admirer of your excellent *Journal*, I have lately perused with interest a paper reported in your August number, for last year, read by Mr. Fairbairn, at a meeting of the "Institution of Civil Engineers," upon the subject of "Ventilating Water-Wheels." To the value of this improvement in hydraulic machinery I am enabled to testify, having erected, in this neighbourhood, as far back as 1843, an overshot water-wheel upon that principle, although with different form of bucket (a description of which I forwarded to England at the time.)



My immediate object in troubling you with the following remarks is chiefly in reference to an observation of Mr. Fairbairn's, which appears to me to require explanation; to the effect, "that the principle of ventilated water-wheels is not so essential to *high falls, being more expensive*." I beg leave to submit the enclosed diagram, which will testify that it is *possible* to avoid the objection of *expense* in such wheels—the cost of such as this certainly not *exceeding* that of the *most simple* of the usual forms of bucket. As regards "high falls," it might be remarked (were it not admitted as an axiom), that such is even the most economical mode of application if the power is "*on the level;*" and, as it cannot but be admitted that the other advantages of the principle are applicable to the overshot wheel (the same necessity existing in these, as in others, "to carry down the water as nearly as possible to the vertical centre, and there allow it to escape with facility"), its application to this description of wheel is equally important, especially where economy of motive power is an object.

The above objects are obtained to a very considerable extent by the angle, and form of bucket, and mode of ventilation, as shown in the diagram. An overshot wheel, 26 feet diameter, has been in successful operation since 1843, realising a great economy of power, with increased effect.

My immediate object at the time of erection was to economise power—the old wheel requiring an accumulation of water during eight hours of the twenty-four. After much consideration, however, of the various improvements which suggested themselves upon Smeaton's form and make of bucket, I determined to *prove*, by confining myself strictly in the new, to the dimensions and materials of the old wheel—I should say, as to diameter of wheel, number and width of buckets, and depth of shrouding; strengthening the arms, however, with right-angular flanges, to obtain "stiffness." At work, the wheel perfectly answered my expectations, the stream being more than sufficient to work the wheel without accumulation, and more efficiently; proving the value of the principle *applied to overshot wheels*—at least, with proper form of bucket.

The form used being quite different to any hitherto adopted—simple and effective, and applicable also to breast wheels, the mode of obtaining it may not, perhaps, be without interest. It is formed by a right angle drawn from the vertical radius, at the inner circumference of the shrouding (at foot of wheel); continued at a slightly decreased angle through the outer division of the shrouding (for the purpose of assisting the retention of the water to the lowest point). The sole of the bucket is formed by the next following radius, intersecting the line or tangent; and the inner line, by the sheathing of the wheel, as high up as the openings left for the exit and admission of atmospheric air; the angle of this being slightly altered from the "circle" to facilitate the passage of air, by its collision with the sole of the advancing bucket.

I adopted the above angle and form of bucket as best adapted to *support and retain the water to the lowest possible level;* and by admitting air to the buckets, my object was not only to effect a rapid discharge of water at that point, but also to facilitate its admission to the buckets at the head of the wheel; not only to insure economy of water, by preventing loss by splashing, but to obtain the greatest possible *effective power*, by *retaining* the water in the wheel.

It might be supposed that an escape, or loss of water, would take place through the openings of the upper buckets; this, however, at a speed of five to six feet per second of the periphery, is not the case, the resistance of the air, whilst escaping through the openings, being sufficient to prevent leakage until the velocity of the wheel has carried round the bucket to a level sufficiently *low* to retain the charge of water. The conical form of bucket assists also the admission, as it facilitates the exit of the water; (the quantity of air admitted at that point is in proportion to the velocity of the wheel.) The wheel is, in fact, *perfectly water-tight*, as it *is released from backward pressure, and exceedingly retentive.* By these means I obtained

Economy of motive power;
Increase of working power;
Freedom and regularity of motion;
"Stiffness," or inflexibility of construction;
Without increase of Expense;

Depth of shrouding should be avoided; extra power obtained by width (or breadth) of wheel.

I can conscientiously advocate the adoption of the principle of "Ventilation" to the "Overshot Wheel;" which application of the system does not appear to have been contemplated by Mr. Fairbairn, and to have been actually considered as *impracticable* by gentlemen present at the meeting.

I am, &c.,

Thos. B. Dodgson, *Manager*.

Ponta de Arca Ironworks and Dockyard,
Rio de Janeiro, May 1st, 1850.

CHEMICAL COMPOSITION OF WATER.

Professor Way, Consulting Chemist of the Royal Agricultural Society of England, delivered a lecture before the members, at their House, in Hanover-square, on Wednesday, the 19th of June, "*On Variations in the Chemical Composition of Water, as affecting its Agricultural Uses.*"

The Professor commenced his lecture by stating, that he intended on that occasion to call the attention of the members to three important heads of inquiry connected with water; more with a view to elicit from them practical illustrations founded on their individual experience, than to offer anything particularly novel or established. These heads of inquiry were the following, namely—1. On Water for Steam and other Boilers: the means of ascertaining its comparative suitableness for that purpose, and of counteracting its tendency to incrustation. 2. On Water for Irrigation: its chemical impregnation, and the theory of its action. 3. On the influence of Water, obtained under different circumstances, on the health of Cattle, Horses, and other live-stock on a farm. He remarked, that as the first head of inquiry related to the mechanical and chemical agency of inert matter, its details came within the range of analytical investigation; and he would be enabled to speak with much confidence on the facts he had to bring together under it; but as the other two heads included a reference to local circumstances, and to the influence of the vital operations of vegetation and animal physiology respectively, in the production of results, what he had to say on these points would be much less decisive, and advanced more for the purpose of seeking than for giving information.

I. *Water for Boilers.*—The water from the clouds reaches the earth almost pure in a chemical sense, as a homogeneous liquid, composed of the elements oxygen and hydrogen. It was distilled from the sea and land, and from the leaves of vegetables in a state of purity, and formed clouds; from which it again fell at intervals to the earth through the atmosphere, bringing with it only very minute traces, varying according to circumstances, and frequently inappreciable by the chemist, of carbonic acid gas, ammonia, nitric acid, and the effluvia arising from animal perspiration and the decomposition of animal matter. On reaching the land, however, its solvent power immediately came into operation, and it became impregnated more or less with the soluble substances with which it came in contact; common salt and gypsum were always dissolved by it, while lime and other substances were taken up by it when there happened to be an excess of carbonic acid gas present. In order to illustrate this fact, the Professor exhibited to the members a simple and striking experiment. Three glass vessels were connected together by means of bent glass tubes; the first vessel contained fragments of marble (as a pure variety of native carbonate of lime); the second, distilled water; and the third and last, a clear solution of quick lime in pure water (or lime-water.) On adding dilute muriatic acid gradually to the marble in the first vessel, carbonic acid gas was disengaged in great abundance, which passing along the tubing into the middle vessel, was there washed and freed from impurity by its passage through the distilled water, and then proceeded, by means of a connecting glass tube, to the lower part of the inner surface, where it continued to bubble throughout the clear lime-water. After a few moments the lime-water became turbid. The Professor remarked, that this effect resulted from the conversion of the lime into insoluble carbonate of lime (or chalk), by its combination with a first proportion of the carbonic acid gas passed through it. In a few moments afterwards, however, the liquid regained its original transparent appearance. This change, he explained, arose from the further supply of the same acid gas, constituting the insoluble carbonate of lime a soluble super-carbonate of that earth; the liquid, in fact, being then a solution, not of lime in water, as it was originally, but a solution of bi-carbonate of lime, or of chalk rendered soluble by excess of carbonic acid. To prove that this was the case, the Professor took the flask containing this solution, and having placed it over a spirit-lamp, caused ebullition to take place. After boiling for a short time, the liquid again became turbid, from the circumstance of the heat expelling the excess of carbonic acid, and again reducing the carbonate of lime to the state of insoluble chalk. He then proceeded to show how this experiment illustrated the change which was found to take place in the waters of limestone districts, which were naturally charged with carbonate as well as the sulphate of lime; and also how it happened that, while water, rendered hard by sulphate of lime only, did no injury to steam-boilers, as that salt was not deposited on raising the water to a boiling temperature; hard water, on the contrary, holding a large amount of carbonate of lime dissolved in it by carbonic acid, did the greatest injury to them, by gradually depositing, on being boiled, such carbonate of lime at the bottom of the steam-boilers, until it amounted to a hard calcareous incrustation.

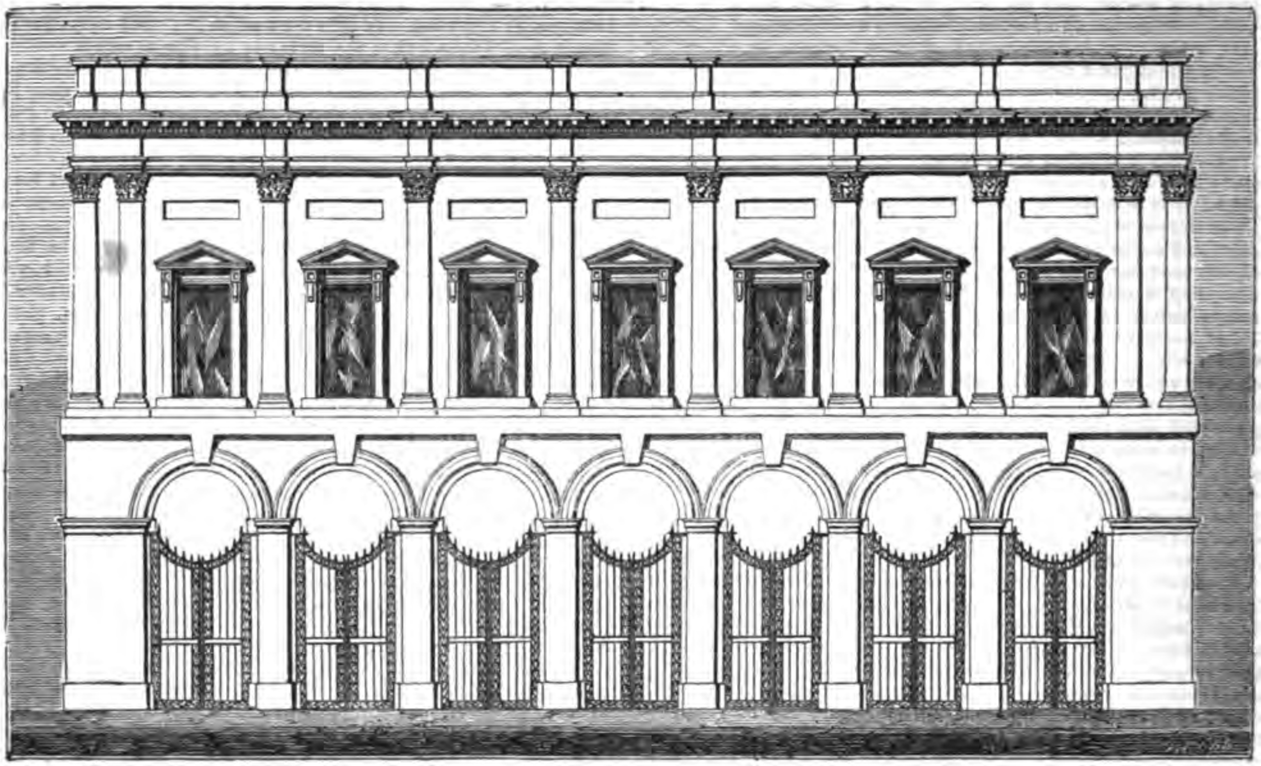
Hard Water.—Water was always rendered hard by holding in solution either the carbonate or the sulphate of lime; and, accordingly, when obtained from wells in the chalk, oolitic, and limestone districts throughout the kingdom, was always hard; becoming turbid when boiled, and depositing its carbonate of lime on that part of the internal surface of the boiler nearest to the fire. As a familiar instance, he named the fur or crust in teakettles, in districts where such water was used; but in the case of steam-boilers, this deposit was one of the greatest evils that could be imagined. The hard calcareous incrustation in immediate contact with the iron plating of the boiler, amounting in a few weeks to no less than from two to three inches in thickness. Professor Way explained how the injury arose in this case—namely, from the effect which the adhering crust had in preventing the transmission of the heat, received by the boiler from the fire, to the body of water within the boiler. He cited many curious instances of the cooling effect of this free transmission of heat on substances under other circumstances most fragile and combustible; and the contrary effect when the transmission of such heat was obstructed, as in the case of calcareous incrustation, when the heat was arrested by the solid slow-conducting body, and the temperature raised above that of boiling water. He stated that, however odd it might sound to make the statement, it was no less true, that water might be boiled in an orange-peel, in an egg-shell, or in a vessel made of thin wood, or even of common writing paper; the heat applied to the external surface being rapidly transmitted to the water, and the heat carried off in the steam generated, while the material employed for the boiler suffered no injurious effect from such application of heat. He related a singular instance of this kind, in the case of a person at Liverpool, who had frequently had his cotton-mill burnt down. The party in question imagined, that if he had a large reservoir for water placed at the top of his factory, constructed of wood instead of metal, the wood, in case of fire, would be immediately burnt to ashes, and the water would consequently be set at liberty and extinguish the fire. The fire unfortunately did break out again, as it was feared it would, but the wood, instead of being charred or burnt, remained entire, and, being encircled by the flames, the water continued to boil in its wooden reservoir as long as any remained. The furring of a boiler preventing this transmission of heat, and thus causing injury to the substance of the boiler, was the reason why, in some districts, where the water was charged with bi-carbonate of lime, the boilers were found to wear out sooner than in others; and why the railway companies had been led either to seek for soft water, or to soften the hard water they had been in the habit of using, by the addition of some substance that would prevent its furring their boilers. The London and South-Western Railway Company had used the substance known in commerce as sal-ammoniac, with great success; by dissolving one ounce of it in 90 gallons of water, in tanks kept specially for the purpose. This substance was the neutral salt, so long familiar to chemists as the muriate of ammonia, being a compound of muriatic acid and ammonia. Its action in removing the hardness of water arising from bi-carbonate of lime was explained by Professor Way in the following manner. When muriate of ammonia and carbonate of lime are brought together in solution, a double decomposition ensues, each of the four combining substances changes its relative position, and two new salts are the result—namely, carbonate of ammonia, which is volatile, and accordingly makes its escape into the atmosphere; and muriate of lime, one of the most deliquescent salts with which chemists are acquainted, and which consequently remains in the water in a state of complete and almost permanent solubility. It might, he remarked, be said, that the ammonia of the sal-ammoniac carried off the carbonic acid, while the muriatic acid dissolved the lime, thus liberating the water from the chemical conditions under which its hardness was occasioned.

Softening Water.—Professor Clark, of the University of Aberdeen, had, however, proposed a plan for softening water rendered hard by carbonate of lime, which Professor Way considered much better than the one just described, and which might be adapted to the uses of agriculturists. This plan consisted in adding to such water a certain quantity of quick lime, which would unite with the excess of carbonic acid, and become converted into carbonate of lime, at the same time that it would reduce by such abstraction the bi-carbonate also to a state of carbonate, and both being insoluble, they would, of course, fall as precipitates to the bottom of the vessel, or other enclosure in which the water was contained, leaving the water entirely free from the bi-carbonate of lime to which its hardness had in a great measure been owing. He then proceeded to describe Professor Clark's system of soap-tests, for ascertaining the relative degrees of hardness possessed by certain waters. He remarked that hard water, as was well known, curdled soap, which would not produce a lather until such hardness had been overcome. Professor Clark had recommended a solution of white curd-soap in spirit of wine of a certain strength to be employed in this testing. This solution would at once produce a lather with soft water, but not with hard water until a certain quantity of the solution had been added to it for the purpose of counteracting the hardness: when lather of a proper firmness had been gained, the amount of standard solution employed to produce the effect indicated the degrees of hardness of any particular water; thus a standard of comparison was established, by which the choice as to different sources from which it would be most advantageous to procure water could be satisfactorily determined. Professor Way then performed an experiment with this soap-test, on spring-water from the chalk at Croydon, in comparison with water from the Thames; the former indicating a hardness of about 18°, and the latter of about 15°. The operation consisted simply in adding to the water, from a graduated pipette or suction tube, successive measures of the solution, until the water when shaken up maintained a lather on its surface for five minutes. The number of measures then indicated the quality of the water, two soap measures being equal to one degree of hardness. The process was described as easy, exact, and simple; and one which might be practised by any gentleman who was interested in such subjects, without spoiling either his furniture or carpets. It would also indicate the hardness resulting from the presence of sulphate of lime, as well as that from the bi-carbonate; though, as he had previously remarked, water hardened by sulphate of lime offered no objection for use in steam-boilers, as the sulphate by boiling did not become deposited, as was the case with the carbonate; in an economical and domestic sense, however, water rendered hard by either of those salts of lime was objectionable. Professor Way then observed, that Professor Clark, in recommending quick lime to soften water containing the bi-carbonate, advised such quantities of lime to be added as a preliminary trial by the soap-test process should indicate as being requisite. Such water would, by this process, be rendered soft for domestic purposes, and for steam and other boilers. The only difficulty consisted in tanks being required for the due subsidence of the chalk thus brought into an insoluble state in the water; but that was an obstacle which would no doubt be surmounted, when it was considered how great the benefit of this plan would be found, not only in ordinary families but in union-houses and prisons; that it was estimated that in London alone 600,000*l.* every year was expended in the purchase of soap, one-half of which was wasted in the hardness of the water; and how important a point it was in the processes of bleaching, dyeing, and other staple manufactures carried on at Bolton, Manchester, Bradford, and other places, to have a soft water in which lime was absent; it would, he thought, be well worth the while of all parties interested in so important a question to make arrangements for the depositing tanks required. The Professor concluded this part of his subject by throwing out hints by which soft water might perhaps be artificially obtained on a large scale, and at little cost, where it did not occur naturally. He remarked, that water was found by experience to become softened by passing through the soil; water, only, however, which was rendered hard by the bi-carbonate of lime. Thames water filtered through clay made permeable by the admixture of sand, was found to become as soft as by Professor Clark's process. Drainage water through regularly permeable stiff soils was more suitable for steam-engines than spring-water. But whether water thrown over the land would by that means become soft, he was not prepared to say. When, however, it was considered that one acre of land received every year on an average 600,000 gallons of pure rain-water, sufficient for the wants of 35 people during that period, it might be a question whether poor sandy land or bad moor land might not be covered with flat tiles for the purpose of collecting the rain-water, which might be conveyed in earthen pipes to the places required for its use. He merely offered this suggestion for the consideration of parties more conversant than himself with the practical bearings of such an undertaking.

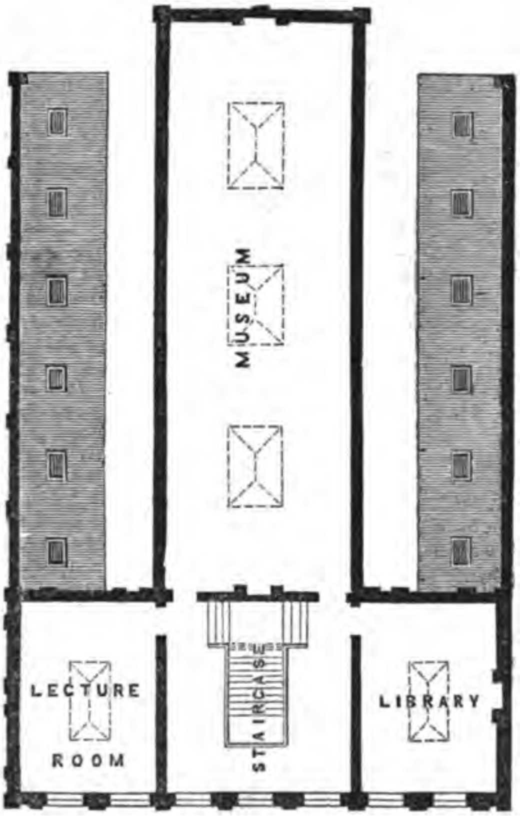
II. *Water for Irrigation.*—Professor Way remarked that, for the purpose of irrigating, he thought that water should be hard, and not soft as for other purposes: that it should contain the sulphates and carbonates of potash, soda, and magnesia, including organic matter, as all these were substances that would be taken up and retained by the land. If this view of the subject were the correct one, it would follow that the water in granite districts would, from its softer nature, not be so useful in irrigation as that in other districts where lime and other earthy substances were dissolved by the water passing through them. On a former occasion Sir John Johnstone had named to the council the failure of some irrigation of his from the supposed circumstance of the absence of mineral and earthy matter in the water, from the water in fact being too pure for the purpose. Sir John Johnstone being thus appealed to, replied that, in the water to which Professor Way had alluded, there was no trace of lime whatever. The irrigation had been laid out by the late Dr. W. Smith on a thin moorland sandstone rock; there was no lime whatever. Professor Way then proceeded to say that, in Derbyshire, and at Bala Lake, in Wales, the water was exceedingly soft and pure, but considered as unfit for irrigation. He felt no doubt that irrigation would become much more general than it had been; and the subject was more interesting at the present time on account of the Society's ensuing country meeting being about to be held in Devonshire, where irrigating operations had been so successfully carried out. He should, on that occasion, select specimens of the different waters, under different circumstances, for the purpose of analysis, in order that he might report, as requested by the chemical committee of the Society, the result of his inquiries on that interesting branch of his researches. It had been found, by ascertaining from analysis the nutriment required by the hop-plant, that only those soils that contained phosphate of lime and potash, would be suitable for the cultivation of that plant—such soils as those on the green sandstone of Sussex, Kent and Surrey; and that what theory had thus prescribed as the condition, practice had actually proved to be the most advantageous in fact, the cultivation of hops having been most successfully carried out on the soils in question. He thought it would also be found, analogically, that successful irrigation would probably be found to be confined to certain districts—namely, to the limestone principally. He thought it might be a question how far the influence of that operation was due to the temperature of the water, or its chemical composition, or to both; he himself considered the chemical nature of the water to be the most essential; at the same time, he was free to confess that we had all to learn upon this subject, and he trusted that an inspection of the Devonshire meadows would lead to further inquiries on the important questions connected with this subject.

III. *Water for Cattle.*—The Professor commenced this third head of his lecture by remarking that he believed it was a generally observed fact, that cattle liked the water of ponds, while they disliked that of limestone springs; that they preferred to quench their thirst in a green offensive collection of stagnant water, rather than in a running spring. In Bedfordshire he had seen cattle much relish a bad water filled with confervæ and animalculæ; which, however, was the only water to which they happened to have access. Farmers generally supposed that the cattle were fond of such water, on account of the green vegetable matter it contained; and a distinguished professor had explained the fact by supposing such water to be "meat and drink" for the cattle. It was certain they did not like hard water; and it gave a staring coat to horses when they were obliged to drink it; and when it was considered that water in chalk districts contained from 60 to 70 grains of carbonate of lime in the gallon, while London water (which was hard compared with others) contained only from 15 to 16 grains, it would be obvious how much difference would be found to exist in different waters. He regarded a good supply of water essential to health, and thought it a point of great importance to ascertain the kinds of water most suitable to the animal economy under different local circumstances. Professor Way concluded his lecture by expressing a hope that the members present would communicate to the meeting such cases of the practical effects of hard water on the health of cattle, as it had been his object, in the remarks he had then made, to elicit from them.

Filter for Sea Water.—M. Cardan lately described at the Academy of Sciences a new system of filtering intended to make sea water drinkable. The apparatus consists of a syphon, the long tube of which is filled with powdered charcoal. The author states that the sea-water after having traversed this syphon has lost its nauseous savour, and that the saline taste which remains is scarcely to be detected after it is mixed with wine. MM. Becquerel and Ponillet are named commissioners to examine into this communication, and we hope it will be tried at sea.

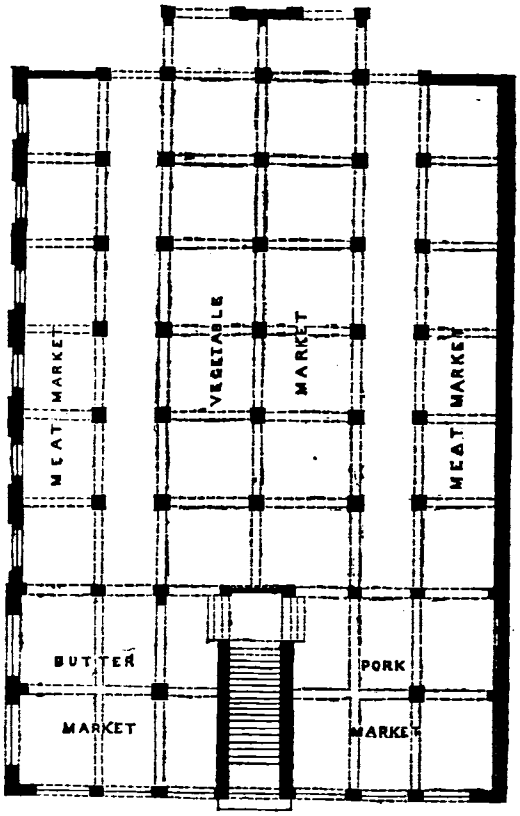


ELEVATION.



PLAN OF MUSEUM.

Scale 24 feet to 1 inch.



PLAN OF MARKET.

DOVER MUSEUM AND MARKET.

Edmund Woodthorpe, F.I.B.A., Architect.

DOVER MARKET AND MUSEUM.

Edmund Woodthorpe, Architect.

(*With Engravings.*)

The building here represented has been lately erected for the purpose of affording to the inhabitants of Dover the twofold advantage of a market and museum. The expense of erecting that portion of the building forming the museum has been defrayed by means of a halfpenny rate—an act having been recently passed for the purpose of favouring such eligible undertakings; the expenses of the market being defrayed from a separate fund dependent upon a toll. The different parties interested in this laudable scheme have united their resources upon the principle of utilitarian economy: hence the very agreeable and profitable result of adding a most valuable and effective feature to the town of Dover.

The market, which serves as a basement to the museum, is surrounded by arcades, and is subdivided in the interior by cast-iron columns, which act as the main supports to the floor above. The staircase leading to the museum springs from a recess within the centre arch of the main front of the building, and is so planned as to completely separate the museum from the market below; The piers of the arches in the principal front are of stone; the remainder of the building is of brick, stuccoed. The building is 63 feet wide by 100 feet in depth; its cost in erecting was 4,000*l.* It has been built from the designs and under the superintendence of Mr. Edmund Woodthorpe, of London.

We congratulate the projectors of this scheme upon having selected so appropriate a style of architecture for their building; the pure Italian style—of which this building presents a graceful specimen—being so completely identified with the growth of intellect and the march of modern civilisation, is in the highest degree applicable to an edifice the chief purpose of which is so illustrative of the progress of learning and the development of taste which mark the present era.

It will be remarked that in the composition of this design, much playfulness of effect is produced by a judicious treatment of very simple materials; the coupling of the pilasters at the angles of the building is an expedient much to be commended in this instance: for this feature not only completes the design which otherwise would appear as a mere portion of a façade, but it produces great variety with apparently but little effort; and is moreover agreeable to reason on the score of giving an appearance of strength to those parts of the building where additional strength is required. In compositions of this kind the coupling of the columns or pilasters at the extremities of the façade should ever be considered as a stringent law. Considering the two very different objects for which this building was erected, the composition as a whole possesses the very great merit of displaying a fit and appropriate character. The establishing museums in our provincial towns is an interesting subject; and one which as regards our own country presents the charm of novelty. We therefore feel much pleasure in selecting it as a theme for further consideration.

WATER SUPPLY FOR LIVERPOOL.

Report of Robert Stephenson, C.E., *on the Supply of Water to the Town of Liverpool.*

(*Continued from page* 235.)

In the outset of this investigation, I certainly was not prepared to find that the multitude of fissures would not enable a greater quantity of water than has been proved by observation and experiment to flow to any given spot, as I was aware of the great facility with which water passes through some of the highly fissured primary rocks, as well as the mountain limestone and some portions of the chalk formation, which sometimes give birth at one point to considerable rivers. The difference is doubtless owing to the fissures being less in the new red sandstone at Liverpool than in those formations, and with such a variety of results, it is evident that experiment in each locality becomes the only true guide to the determination of the actual resistance offered by any particular formation to the free passage of water. The trials now brought together, which have been made in and near Liverpool, would appear to show distinctly that a larger supply, from one point, than about 1,000,000 gallons a day cannot be safely calculated on; and several distinguished scientific men and engineers concur in this opinion. It also appears that the wells, to yield large quantities of water, must be at considerable distances apart.

With the conviction thus impressed on me that none of the plans hitherto suggested is adequate to the supply of the present and prospective wants of Liverpool, and, as no efficient scheme has, to my thinking, been brought forward for rendering fully available the supply of water in the sandstone, I venture to devise a system of independent wells, placed throughout the district, and lying generally to the east of Liverpool; and the stations at Green Lane and Windsor, so often already referred to, afford again materials for estimating the cost of such a plan, without liability to material error.

The cost of the Green Lane pumping establishment, exclusive of that of mains, is already stated to have been about 19,000*l.* and the Windsor station nearly 30,000*l.* The former is scarcely complete, having no cottages for the engine-men and firemen; and the latter has a valuable parcel of disposable land attached to it. But judging from these instances, I think the cost of each of the new stations at a greater distance from the town may be fairly taken at 20,000*l.* The price of the land might, from the localities, be somewhat less than at the existing stations, while engines of greater power would be required. Green Lane and Windsor are together equal to the supply of 2,000,000 gallons a-day; so that, assuming that they will continue this supply permanently, and that the total quantity required is 8,000,000, six new stations must be constructed, which, at a cost of 20,000*l.* each, will amount to 120,000*l.*; and as the mains connecting them and the storage reservoirs at Kensington will cost about 48,000*l.*, there will be (with 10 per cent. for contingencies) a total cost of 185,000*l.* requisite for the present supply; and for 11,000,000 of gallons, which will be required at the end of about 10 years, the cost will amount to 277,000*l.*,—an amount apparently in excess of the calculations already given, but in fact quite consistent, as the relation between the cost and supply cannot remain the same for quantities from different distances.

The first objection which will perhaps be made to this plan is, the want of concentration, upon which so much stress has been laid, and which in some manufactures is doubtless the very essence of cheap production; but it is not so applicable in a case of the present kind. The chief argument that has been adduced in its support rests upon the opportunity it is supposed to afford of dispensing with duplicate engines; whereas, with so many constantly at work, the failure of one will produce slight inconvenience, and the objection may be entirely obviated, by having an additional station, to be worked in case of need. Besides which, in supplying a town varying in level from a number of detached pumping stations, the water need not all be pumped to the highest reservoir, and the saving of power would fully compensate for any advantages derivable from the concentration of the establishment, while economy would result from the substitution of mains for tunnels.

The following estimate of the annual cost of working this system of wells is based upon the actual cost of Green Lane and Windsor, where the expense of obtaining 1,000,000 gallons a-day from each is:—

For current expenses including superintendence ..	£1100
Depreciation upon engines and machinery, engine-houses, and cooling-pond, £11,200 at 2 per cent.	224
Total	£1324

And at each new station the corresponding expense will be—

For current expenses, including superintendence ..	£1100
Depreciation upon engines and machinery, engine-houses, and cooling-ponds, £12.000 at 2 per cent.	240
Depreciation of mains, £8000 at ¼ per cent.	20
Interest on capital—namely, £30,800 at 4½ per cent..	1386
Compensation to landowners	250
Total	£2996

The annual expense of obtaining any number of million gallons a-day can now be readily arrived at, and the following table shows it from eight to fourteen millions:—

To obtain	8 million gallons.		2 old stations—		6 new.	Cost a year	£20,624
..	9	..	2	..	7	..	23,620
..	10	..	2	..	8	..	26,616
..	11	..	2	..	9	..	29,612
..	12	..	2	..	10	..	32,608
..	13	..	2	..	11	..	35,604
..	14	..	2	..	12	..	38,600

These calculations, if not exact, are certainly such approximations as will justify their application in a comparison with other projects; and, in concluding my remarks upon this proposal, I am not insensible to one or two grave objections which may be made to it; but after much deliberation I am persuaded that distributing the establishment over a wide area of country is the only sure method of obtaining the requisite supply of water.

The length of connecting mains is the first obvious objection, but they would be less costly than the amount of tunnelling necessary for connecting works even much less widely spread. Another objection is the payment of a royalty to landowners for the abstraction of water, of which I am unable to form any very accurate estimate, but do not think that the amount now paid to the Earl of Derby at Bootle ought to be taken as a basis for calculation. The remaining objection which is urged against a divided establishment consists in the necessity for some additional superintendence, but this is too trivial to operate while the present necessity for a supply of water exists, which I am convinced can only be adequately derived from the sandstone by such means.

Mr. Hawksley's Proposed Supply from Rivington.

The third question submitted is—

"*Whether such supply can be obtained by means of the Rivington Works, and the cost of obtaining and distributing the same as recommended by Mr. Hawksley?*

In order to become thoroughly familiar with all the details of this undertaking, I first visited the locality, accompanied by its projector, for the purpose of receiving his explanations personally on the spot, and to satisfy myself by actual inspection of the reasonableness or otherwise of his anticipations, both as regards its cost and capability of supplying the very large quantity of water calculated upon by him; and at the same time to examine several other extensive reservoirs in the adjoining districts. Shortly after this I went again to Rivington with Mr. Simpson, Mr. Newlands, Mr. Rowlandson, and Mr. Binny, in order to receive from them in like manner a detail of their objections, and, in addition to this, make myself master of the whole of the views and calculations developed in the printed report of the two first-named of these gentlemen; and having done this, I carefully reviewed every difficulty that had been raised.

The first was, that the reservoirs were incapable of storing such an amount of flood-water as would maintain the uniform supply of 13,660,000 gallons a day to Liverpool, and 8,000,000 gallons a day to millowners and others throughout the usual as well as unusual droughts which sometimes occur, and that the fluctuations in the quantity of water were so extensive that at some periods of the year the reservoirs would be absolutely empty.

If even a near approach to such a state of things were probable, this objection would at once be fatal. I therefore made myself acquainted with the mode of calculation by which this is said to be proved, and which may be succinctly described as follows.

A series of rain-gauges had been carefully registered in the Belmont District, from the year 1843 to 1848 inclusive; and during the years 1847 and 1848 a similar series was also registered simultaneously by the projector of the Rivington Works in that district, with the view of establishing a relation between the amount of rain-fall in both; and the proportion found to exist was applied to the four preceding years, thus arriving at the probable rain-fall in the Rivington district during the whole six years. This mode appears quite unobjectionable, provided the levels occupied by the rain-gauges in the respective districts are identical, which is an essential condition in consequence of the total amount of rain varying very materially at different elevations.

During the years 1847 and 1848, the actual quantity of rain which flowed down the brooks of the Rivington district having been accurately measured, the proportion of available water was ascertained to be within 18 or 19 per cent. of the whole rain-fall. The quantity during the four preceding years was then modified according to the amount of fall and evaporation, and the annual yield largely reduced by the assumption that the latter was considerably greater in the drier years. These total amounts were next apportioned to each month in the four years in accordance with the registration of the Belmont rain-gauge, and thus what was supposed to be the monthly supply to the reservoirs was arrived at. The draught upon the reservoirs was then taken at a mean of 21,660,000 gallons a-day, and this quantity altered to the extent of 19 per cent. less than the mean quantity to be appropriated to Liverpool for the winter months, and a like per centage more for the summer months. It then became easy to institute a debtor and creditor account between the demand and the supply upon the reservoirs, which account exhibited the reservoirs occasionally in a state of bankruptcy.

Several objections have been urged to this mode of arriving at the result. In the first place, the total rain-fall at Rivington during the years 1847 and 1848 was obtained by averaging that represented by a series of rain-gauges, the average of which is stated by Mr. Hawksley to have occupied a position below the mean level of the area of the water-shed, and in the next place the assumption of the available quantity being in dry years less than four-fifths of the total rain-fall on the water-shed, from a supposition that the proportion wasted by evaporation was much increased; and again, that the allowance of 19 per cent. above and below the mean quantity of 13,660,000 gallons is too great; and objection is also taken to the supposition that the monthly supplies to the reservoirs are proportionate to the monthly falls of rain. This was established by reference to the tables contained in Messrs. Simpson and Newland's Report; as it appeared that in December, 1847, 8 inches of rain fell at Belmont, and 1,604,000,000 of gallons were discharged by the brooks at Rivington; whereas in December, 1845, a like quantity of rain fell, and the flow from it is calculated to yield only 1,080,000,000; and many other instances might be referred to where the same inconsistency was shown, by which the calculated quantity was sometimes more and as often less than that which was measured in 1847 and 1848.

In the objections to this project, great importance is attached to the circumstance of the mains passing over an extensive coal-field, it being said that they will consequently be liable to fracture by subsidence when the coal is worked away, and that injury may be anticipated to mines from inundations. This, at the first glance, certainly appears formidable; it was deemed so in reference to railways some years ago, and was used with success in preventing the Grand Junction passing through the densely populated mining district at South Staffordshire. The demand for accommodation, and a more dispassionate consideration of the difficulties to be expected from this source have led to its being discarded; and indeed the conclusion might have been arrived at without diverting a great line of railway out of its proper course, by the experience of the canals which intersect extensively every part of the same coal-field where the beds are very thick, and give rise sometimes to extensive subsidences. In spite of these, however, no serious impediments have arisen. Attention, of course, is essential to those parts of the canal or railway under which it is known that the operation of mining is going on; and for the purpose of protecting the public against inconvenienae as far as possible, by the extraction of coals or other minerals without the knowledge of the companies, it is made imperative on the mining proprietors to give due notice of the advance of their operation before they work under any canal or railway; and similar provisions, I believe, are applicable in the case of waterworks. This objection, therefore, I regard as of little moment in the Rivington scheme, provided in other respects it may prove the most eligible source of the supply of water to Liverpool.

Without entering here into further discussion of points which are rather of detail, and could not be made intelligible within any reasonable compass, I will state the manner in which I have proceeded to investigate this part of the subject.

There is some discrepancy in the statement of the rain-fall at Rivington in 1847 and 1848, Mr. Hawksley averaging it at 55·5 inches and Mr. Newlands at 51·7 inches; but the difference (however occurring) is of little importance in this inquiry, as the quantity of water flowing down the brooks in these years has been actually measured, and amounts to 25,718,194 gallons a day.

The years 1847 and 1848 having been wetter than the average of years, it is necessary to arrive by estimate at a fair average yield from such data as exist. The Belmont rain-gauge supplies the means of doing so, and I find, by its register, that while the years 1847 and 1848 show an average of 63·6 inches, the average of the six years (1843 to 1848) gives only 57·57 inches. These figures furnish a proximate ratio by which the yield of the brooks in 1847 and 1848 ought to be corrected; and, following them, the

		Gallons a day.
Measured quantity of 25,718,194 gallons is reduced to ..		23,279,818
Which may be assumed as the permanent yield of the district; but this, as regards Liverpool, is again subject to the following deductions, in the way of compensation to		
Mill-owners	7,500,000	
Chorley and outlying population, say ..	500,000	
Wigan	800,000	
And for waste by additional evaporation from the reservoirs	422,103	

Amounting together to	9,222,108
And leaving for Liverpool	14,057,710
But by Clause 59 of the Act the Corporation are in effect empowered to supply Wigan from another source with ..	800,000
And under Clause 62 to contract with other parties for the compensation down the Roddlesworth for	1,846,000
So that there is available for Liverpool, supposing the powers of Clauses 59 and 62 to be acted upon, ...	16,703,710

The capacity of the reservoirs is stated by Mr. Newlands to be 2,849,000,000 gallons, and by Mr. Hawksley 3,156,000,000 gallons; which difference is caused by the addition, when required, of two feet to their depth by moveable shuttles or flush-boards on the weir,—an intention probably unknown to Mr. Newlands.

The yield per day or month is only known during 1847 and 1848, and its irregularity is so great even in these years as to render it impossible to calculate with accuracy upon the quantity a month of any other year by the rain-fall only. As an instance of this, taking the month of January in each year, we find that in 1847 an inch of rain-fall produced 330,500,000 and in 1848 only 216,100,000, although in the previous month of December, 1847, 8 inches of rain had fallen, and in December, 1846, only 3·9 inches. Again, in February, 1847, one inch yielded 266,900,000, but in February, 1848, only 147,100,000, although in the month of January, 1847, only 1·9 inches of rain had fallen, and in January, 1848, 3·1 inches. This is sufficient to show the absence of a rule which would justify the construction of any balance of account for each month of those years when the actual flow was not measured, and I have therefore made out tables, showing the quantities flowing into, abstracted from, and left in the reservoir during 1847 and 1848, and propose from them to be guided in reference to the capabilities and equalising effect of the reservoirs during other years.

In these two years, 22,800,000 gallons a day might have been taken out, and still have left the reservoirs full at the end of them, and never containing less than 1,376,580,000 gallons, but in the six years from 1843 to 1848, 2,400,000 gallons a day less water woud have flowed into the reservoirs, which would have reduced this minimum quantity to about 950,000,000 gallons.

It may be fairly assumed that practically the storage capacity proposed (3,156,000,000 gallons) is sufficient to ensure the supply of about 12 or 13,000,000 gallons a day with the whole compensation, or of about 15,000,000 gallons a day with the compensation reduced according to clauses 59 and 62 of the Act of Parliament; and there will be little difficulty and no considerable expense in raising the embankment so as to increase very largely the capacity of the reservoirs, as all the lands on their margin up to a level of five feet above the present top water mark can be purchased according to the notices which have already been given, and thus a supply to Liverpool of 14,000,000 gallons a day with the whole compensation, or of 16,000,000 gallons a day with the reduced compensation, may be insured.

In support of the adequacy of the storage room, the case of the Belmont Reservoir was adduced, which, with a water-shed of 1800 acres and capacity of reservoirs of 75,000,000 cubic feet, supplies 15 feet a second for 12 hours a day on 313 days a year, or 3,463,011 gallons a day of 24 hours throughout the year. The proportion of the water-shed is about one acre to 41,666 cubic feet of reservoir; and, comparing the two reservoirs, the Belmont having delivered 3,463,011 gallons, that proposed at Rivington, with a water-shed of 10,400 acres, will be capable of delivering 23,383,103 gallons a day.

The area of water-shed of the Bolton Waterworks is 520 acres, the capacity of reservoir being 20,860,077 cubic feet, and the evidence of Mr. Jackson is to the effect that 900,000 gallons is supplied to Bolton a day, or 18 gallons to each individual. The proportion of water-shed to the content of the reservoir is one acre to 40,115 cubic feet, while the proportion at Rivington is an acre to 48,694 cubic feet. At the Manchester Works the proportion of area of water-shed and capacity of reservoirs is an acre to 34,000 cubic feet.

The statement is made as independently as possible of any assumption or hypothesis in reference to the periodical supply to the reservoirs, or the variable loss which may be due to evaporation; the meteorological facts positively established in relation to the Belmont district, being alone taken as the basis of the calculations for the purpose of analogy. The rain-fall at Belmont during the years 1847 and 1848 is compared with the actually measured discharge of the streams from the Rivington district during the same period; but as this was an unusually wet period, the average discharge of the latter district is reduced, as before stated, in the proportion pointed out by the Belmont rain-gauges over this period, and that of six years, and the only source of error which I can discover in the process arises from the possible concurrence of two or three very dry seasons consecutively.

The mode of calculation which I have adopted does not fully justify the expectation of obtaining a daily supply of 16,000,000 gallons, together with the quantity required for compensation, although expedients are within reach at a moderate expense to realise this quantity. The results leave so considerable a margin as regards the storage capacity of the reservoirs, that an uniform supply of 12 or 13,000,000 gallons a day may, in my judgment, be reckoned upon with absolute certainty.

Mr. Hawksley's estimate for engineering works and land amounts to 389,800*l.*, of which 213,400*l.* is for the main pipe, leaving 176,400*l.* for the remaining works and land.

The only large item in this estimate to which the scale of prices does not apply, is in the laying of the main pipe from Rivington to Liverpool, and on this portion of the work the contingencies may be considerable; but on the whole of the remainder of the items in the estimate I do not believe that more than the usual per centage for contingencies is necessary. This observation, however, is not to be taken as applying to the item of *land*, of which valuations have been made by three parties appointed by the Corporation, and their estimate amounts to 39,408*l.*, — a sum which, although much beyond the agricultural value of the land, will, from my experience in such matters, fall short of the actual cost. In the evidence of this item given before me, great stress was laid upon the onerous severances that would be occasioned by the construction of wide reservoirs, which it would be impracticable to mitigate by the formation of roads and bridges. This led me to inquire into the facts, and to examine the plans on which the various properties are designated, and they show that with one or two exceptions no actual severance will occur, in consequence of the brook leading from the head of the Anglezark Reservoir down to Horwich forming generally the boundary of the estates and townships.

In considering the adequacy of the estimate for engineering works, I have, as already stated, been guided by the prices which have been paid in this as well as other districts; and, in addition, a tender was produced in the course of the inquiry from a respectable contractor well acquainted with the locality, and who had examined the proposed works, offering to execute them on a scale nearly identical with those contained in Mr. Hawksley's estimate.

To the estimated cost of the land and works, I have added 25 per cent. to cover unforeseen works and superintendence, making the total amount 487,250*l.*; and I believe that the Rivington project is adequate to the present and prospective supply of the town of Liverpool, and may, together with all compensations, be realised at a sum of (say) 500,000*l.*

The annual expense on the supposition of a supply of eight million gallons a-day by these works, including the depreciation of the main, will be	£5,600 0*s.* 0*d.*
To which is to be added the interest on the capital of 500,000*l.* say at 4½ per cent. ...	£22,500 0*s.* 0*d.*
Giving a yearly charge of	£28,100 0*s.* 0*d.*

And for further supplies there will be an additional charge by reason of the increase of interest for money expended on filter-beds and the cost of maintaining them.

(To be continued.)

WATERWORKS IN THE UNITED STATES.

A good sample of the water supply of the American second-rate towns is to be found at Richmond, in Virginia. It consists in two water wheels (set in motion by the James River), of 18 feet diameter, by 10 feet wide, with a 10 feet fall; they are undershot. The pumps are 9 inches diameter, with a 6 feet stroke, and they lift 400,000 gallons every 24 hours for each pump. The reservoirs are placed at a height of 160 feet above low-water mark in the river, and are two in number, each being 194 feet long, by 104 feet wide, by 10 ft. 8 in. deep. The pipes from the pump-house to the reservoirs are 8 inches in diameter; and there are two filters through which the water passes previously to being distributed. The total cost of the works, without including the distribution, was about 20,000*l.*

At Philadelphia, the supply is effected by a very important water mill, established upon the Schuylkill, near Fairmount. A dam was thrown across the river 1600 feet long, so as to deaden its velocity for a distance of six miles up the country, and to maintain a constant depth of water at the dam of 24 feet. The dam itself is inclined at an angle of 45° to the current. A canal for the navigation is constructed 900 feet long, with two locks of 6 feet fall each, opposite to the mill race. The mill race itself, in ordinary states of the river, offers an opening of 68 feet wide by 6 feet high. It can be closed at the head, and an overflow sluice is constructed to carry off the water in this case, without passing through the wheels. The race is 419 feet long, by 140 feet wide, and from 16 to 60 feet in depth.

The engine-house is built for 8 wheels and pumps; each pump lifts actually 530,000 gallons per 24 hours. It is calculated that one gallon of water raises one other gallon into the reservoirs by its action on the wheels; but this action appears to be considerably exaggerated. The wheels are 16 feet diameter, by 15 feet in width, and they make 13 revolutions in a minute; they are capable of functioning even when there is 16 inches of water over the wheel. The floods, indeed, are a serious inconvenience upon this river, for they appear to cause the mills to lose 64 hours every month. The pumps have 6 feet stroke; the water is lifted 92 feet into the reservoirs, through cast-iron pipes 16 inches diameter. The reservoirs are situated at 102 feet above the low-water mark of the Delaware, and 56 feet above the average level of the streets of Philadelphia. They are four in number, covering a surface of 6 acres, with a depth of 12ft. 3in., and they contain 22,000,000 gallons of water. The cost of constructing these reservoirs was about 29,000*l.* sterling. In consequence, also, of the very intelligent manner in which the engineers have availed themselves of the natural power furnished by the river, the annual expenses incurred to secure a supply of 3,122,644 gallons daily are only about 2,800*l.* per annum.

The Croton Aqueduct of New York is, however, the work upon which the American engineers pride themselves the most; and it must, in justice, be allowed to be an extraordinary work, although far inferior to many of those we have hitherto considered. This aqueduct was constructed at the expense of the city of New York, under the control of a commission of the Common Council. The preliminary surveys appear to have been made by Mr. David B. Douglas, and the works were executed under the superintendence of Mr. John B. Jervis.

The Croton River takes its rise from a series of large ponds, or lakes, the aggregate of whose surface areas is about 3800 acres, which are principally situated in the county of Putnam, at a distance of about 50 miles from the city of New York. The dam built for the purpose of forming the fountain reservoir is situated about 38 miles from that town; and in the precise locality in question the medium quantity of water flowing in the river is above 50,000,000 gallons in the 24 hours, whilst in seasons of drought it has never been known to fall short of 27,000,000 gallons.

The dam across the Croton is in this place raised 38 feet above the level of the river in its natural state, and by this means it sets back the water six miles up the country, forming the fountain reservoir, whose surface is 400 acres. Excavations were made wherever the shores assumed a gentle slope, so as to create a minimum depth of water of at least 4½ feet. The available capacity of this reservoir, down to the level where the water would flow off by the aqueduct, has been estimated to be equal to 600 million gallons. The height of 38 feet, quoted above, is the height at which the aqueduct receives the water from the reservoir. The surface of this fountain reservoir is 166⅛ feet above the mean level of the tides at New York; the surface of the receiving reservoir on the island is 119 feet above the same level; so that the total fall from the one to the other is 47⅛ feet. The distributing reservoir is 115 feet above the mean level of the tides, and regulates the height to which the water can be delivered in the city.

The water is led from the fountain reservoir the whole length of the way in a closed conduit of masonry, except in crossing the river Harlem to reach the New York island, and in passing a deep valley in the island itself. In these cases, as the principle of the syphon was employed, cast-iron pipes were introduced.

The general description of the conduit may be considered to be as follows:—A bed of concrete is formed, consisting of three parts of sand to one of hydraulic lime worked up into a mortar, and then mixed with three parts in bulk of sharp gravel or broken stone to one of mortar; well rammed in place, not shot in, as is our very absurd English practice. Upon this the side walls are executed in rubble stone set in hydraulic mortar in the above proportions. The face of these walls is then rendered with a coat of hydraulic mortar, about ⅜-inch in thickness, which is also laid on the concrete. The proportions of sand to lime in this rendering coat are two of sand to one of lime.

A facing of sound, hard, well-burnt, and carefully selected bricks, is then built up in hydraulic lime upon this coat of rendering, mostly of half-a-brick in thickness for the sides and the invert; the top is vaulted over in two half-brick rings; and, wherever it is possible, covered with four feet of earth, to remove the aqueduct from the influence of the external atmosphere. The width of the conduit at the bottom is usually 6 ft. 9 in.; at the springing of the semicircular vault 7 ft. 3 in.; the versed sine of the invert is 9 inches; the height from the chord line of the invert to that of the vault is 4 feet. Occasionally the form of the conduit varies; but the above may be considered as the general description. Under all circumstances, it is made so as to receive and to discharge 60,000,000 gallons in the twenty-four hours.

In traversing valleys, the conduit is carried upon a wall of solid masonry, executed in rubble stone, set in hydraulic mortar. The whole is then covered over with earth, carefully rammed, and the slopes pitched with dry stones. These precautions are necessary to secure the water from the severe frosts of the North American winters. The dimensions of the concrete floor of the side walls, and of the spandril filling, are increased; and the proportion of hydraulic lime to sand is augmented to one of lime to two of sand, for all parts of the work. Great pains were taken to secure the stability of the aqueduct when it was carried upon the hill side, by forming culverts, or paved drains to carry any torrential waters away from the foundations, which were cut into the hills.

Waste weirs, with sluice gates, are provided for the discharge of any surplus water, or for the purpose of leaving the aqueduct dry in case repairs should be required. There are six of these weirs in the length of the aqueduct.

Ventilators, formed of hollow cylinders of stone, 14 feet above the surface of the ground, are placed at distances of one mile apart; and every third one is made with a door to admit of inspection of the conduit. The interior diameter of the common ventilators is 2 feet; that of the ventilators with doors, 4 feet. The latter are placed by the side of the conduit, to give room for a staircase leading to the bottom; the cill of the door being made 12 feet above the lowest point of the invert. The ordinary ventilators are placed immediately upon the centre line of the aqueduct. All of them are covered over with iron gratings. Besides these ventilators there are man-holes, placed every quarter-of-a-mile asunder, about 2 feet square. They are covered with a stone damper.

The Gate-chamber at the fountain reservoir is established nearly at the bottom of the artificial lake, and is situated at the extremity of a tunnel about 200 feet long, which separates it from the reservoir itself. The centre of the tunnel is 12 feet below the surface of the water; so that floating bodies are not likely to be carried into it, nor during the winter season can any intermission take place in the supply from the reservoirs being frozen. In summer also the water will be drawn from a level where it is at a lower degree of temperature than at the surface. At the Gate-chamber are the regulating gates, and the guard gates, necessary to controul the supply.

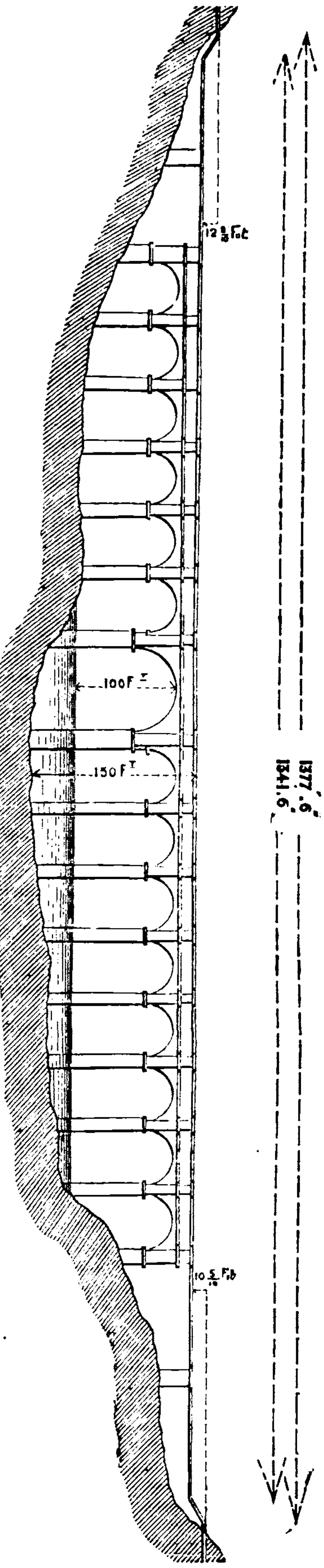
The total distance between the fountain reservoir and the receiving reservoir is 201,117·42 feet, or 38·09 miles. The total fall is $43\frac{88}{100}$ feet. The least incline is 7⅛ inches in a mile; the greatest is about 13¼ inches per mile. The syphon upon the Harlem River Bridge is 1377½ feet long, with a difference of level between the two extremities of 2·29 feet. The other syphon in the Manhattan Valley is 4105 feet long, with a difference of level of 3·86 feet, to overcome the friction in the pipes.

The depth of the water in the aqueduct at its entry into the fountain reservoir is $7\frac{55}{100}$ ft. above the bottom of the invert. The average sectional area of the aqueduct is made 53·34 square feet. The curves used to change the direction of the line of the aqueduct are never less than 500 feet; some have a radius of 1000 feet; but 500 is the radius usually adopted in preference. The velocity of the water has been ascertained to be 1½ mile per hour, when there is 2 feet depth of water in the aqueduct.

During the construction of the dam at the fountain reservoir, and very shortly before the completion of the works, a most extraordinary flood took place, which carried away the greater portion of the dam, and spead ruin and desolation through the valley. Dwelling-houses, mills, and everything the stream met with in its first fury, were swept away, and three lives were lost. In repairing the dam, the breach was filled-in with masonry instead of earthwork, and it has since resisted very successfully. The masonry of the dam is 8 feet wide at the top and 65 feet wide at the bottom, vertical to the stream, with occasional off-sets. The lower or down side has a curved face, so that the water does not fall vertically upon the apron at the foot. In order to guarantee the foot of the dam against the undermining action of the cataract, a secondary dam has been formed at a small distance to retain a head of water over the apron, so as to break the force of the water falling upon it. On the upside of the masonry of the dam a slope in earth, with an incline of 1 in 5, is executed, extending 275 feet into the reservoir at the foot. The whole length of the overfall is 251 feet.

In the course of the passage from the fountain reservoir above 11 tunnels and 14 small bridges were executed. At a point called Sing-Sing-Kill, there is, moreover, a bridge traversing a small stream of 88 feet opening, with a rise of 33 feet, of an elliptical form. The bottom of the ravine is 70 feet below the underside of the key, so that we may fairly ask why the engineer should have gone out of his way to employ the most difficult and expensive form of arch, instead of at once making it a semicircular one? The bridge over the Harlem River is, however, the great boast of our transatlantic brethren. The height from the foundations in the river to the top of the work, is 150 feet; the width across the top, 21 feet. The distance between the extremes of the pipes is 1377½ feet; for the distance of 18 feet at each end there is an inclination, the rest is upon the level. The bottom of the pipes is below the level of the aqueduct, on the upper side 12$\frac{4}{10}$th feet; on the lower it is 10$\frac{4}{10}$th feet.

On the south side of the river there is an arch of 50 feet span; across the river there are eight arches of 80 feet span each; and on the north side there are six arches of 50 feet span each; making in all 15 arches. We may justly question the policy of the engineer who has burthened the water supply with the maintenance of these syphon pipes for the sake of saving, at most, 12½ feet of additional masonry in the piers.



Croton Aqueduct, Harlem River, New York (U.S.)—Date about 1840, A.D.

There is a very important syphon in the Manhattan Valley, which carries the water over a depression of 102 feet in the deepest part. Provision is made for laying down four pipes, 5 feet in diameter. Temporarily only two are fixed, which are sufficient for the present demands of the city.

The receiving reservoirs are skilfully constructed, with a depth varying from 20 to 30 feet of water. The retaining walls are executed partly in masonry towards the streets, with a batter of 1 in 3; the inside is of earth, puddled, and covered with dry pitching, laid and dressed off to a slope of 1½ to 1. The total surface of these reservoirs is nearly 31 acres; their contents are estimated at about 150,000,000 imperial gallons.

The distributing reservoir is situated about two miles from the receiving reservoirs. It is 420 feet square on the top, with about 36 feet depth of water when full, and is calculated to hold about 20,000,000 gallons.

The total cost of the aqueduct and the reservoirs was about 9,000,000 dollars, or 1,800,000*l.* sterling, without including the pipes for the town supply. These latter, added to the above cost, make the total expense incurred by the municipality for its water supply amount to the sum of 12,000,000 dollars, or 2,400,000*l.* nearly.

Geo. R. Burnell.

PURIFYING AND FILTERING WATER.

On the Purifying and Filtering of large bodies of Water for supplying extensive and populous Towns. By James Henderson, C.E., Glasgow.

Rain water, immediately after it has fallen, is generally considered the purest of all natural waters, and being the great source from which all streams and rivers are supplied and more easily obtained in large quantities than spring water, it forms the best supply for large and populous towns. But as the rains which fall on the surface of the earth collect and flow from their various sources into their different channels, and from thence into the streams and rivers which convey them back again to the ocean, they become impregnated with various earthy, mineral, and organic substances. With many of these, owing to the great solvent power which water possesses, it chemically combines; while with others it forms only a mechanical mixture, the impurities being simply held in suspension. These latter impurities, together with all insects, animalculæ, &c., can be removed by a proper system of filtration; but those which are chemically combined with the water cannot thus be separated.

The nature and quantity of the impurities in streams and rivers depend on the nature of the contributing ground, and the state of the weather; which causes, and more especially the latter, produce great variations in their purity—the same stream or river which, during a succession of fine weather, is comparatively pure, becoming, during heavy floods, loaded with a large accumulation of earthy and other impurities. This being the case, it is highly essential, that before water is let on to a filter, it should be impounded in a reservoir, so as to purify to a certain extent by subsidence.

When the stream which supplies the town is not large enough to admit of giving a sufficient quantity at all seasons of the year, the impounding of the waters becomes, of course, one of the main principles of the system, in order to retain a sufficient supply in storage when the run in the stream is deficient in dry summer weather; but when the river is large enough at all seasons to give an adequate supply, it still becomes highly essential first to impound its waters in a reservoir for the sake of subsidence; and the larger that reservoir can be obtained, so much the better. In some waterworks, where the supply is from a large river, the principle of subsidence is particularly attended to, while in others the water is taken directly from the river on to filter; thus greatly increasing the difficulty of supplying pure water to the inhabitants at all seasons. Indeed, in all such water-works during heavy floods, except where some peculiarly advantageous circumstances exist, the supplying of the inhabitants with muddy water becomes almost unavoidable, the filter bed in a short time becoming so much loaded with silt as to be incapable of passing a sufficient supply, and to make up the deficiency the water has to be sent in as it comes from the river.

The impounding of the waters in large reservoirs, besides being advantageous by allowing many of the impurities to subside, owing to its thus being more exposed to the influence of the sun and air, and the action of the winds, the waters are still further purified, as they have a tendency to give off, when thus exposed, many of the gases they may have combined with during the decomposition of animal and vegetable matter, which gases cannot otherwise be removed by filtration: it has likewise the effect of removing hardness from the water, and rendering it more fit for all domestic and other purposes. The Thames water, for instance, owing to its being much loaded with organic matter received from the towns and villages on its banks, after being kept for two or three months in a closed cask, when opened, the water is found to be black, nauseous, and unfit for use; but on being exposed and agitated it deposits a quantity of slimy mud, and becomes clear and sweet.

The water, after having been allowed to subside, the next point to be attended to is the process of filtration, in order to remove all the remaining impurities. In all filters, the great principle to which attention should be most particularly directed, is that of having a large extent of filtering surface, it being greatly owing to want of attention to such an important point that is to be attributed the inefficiency of the filters of many water-works. The great aim in the construction of many filters, is that of having the bed of sufficient fineness, so as to prevent the impurities from passing through, causing the filter bed thus to act like a sieve. Besides this, however, in order to filter water thoroughly, another important principle should be brought into operation—namely, that of attraction; and the only way by which advantage of this principle can be obtained, is by having a large filtering surface, so that the water may percolate very slowly through the filtering material.

If a stone, for instance, be suspended in muddy water, it will be found very soon coated all round with the impurities in the water, caused by the attraction which exists between the impurities and the stone, the latter, as it were, forming a nucleous to which these impurities adhere. On the same principle, if the water is allowed to percolate very slowly through the material composing the bed of filter, while the whole surface will still act like a sieve to prevent the passage of many of the impurities, each particle of the material is brought more fully into operation in removing the finer particles of the impurities carried along with the water. The filtered water is thus rendered more pure and pellucid; very fine material becomes unnecessary, and the filter bed will continue for a much longer time in good and efficient working order.

When the filter bed is too small, as the water must of course pass quickly through, fine material becomes almost indispensable, to prevent the quick percolation of the water from carrying many of the impurities with it; the consequence is, that it soon becomes silted up, and requires continual cleansing; and previous to being cleansed, recourse is not unfrequently had to that of forming holes in the material, in order to make it more open; or, as I have already observed, filter as much as they can, and make up the deficiency by unfiltered water. It may, indeed, be taken as a general principle, that the smaller the bed of filter, in proportion to the amount of filtered water required, the finer must be the material it contains, in order to remove the impurities; and, on the contrary, the larger the bed the coarser the material.

With regard to the speed with which the water should be allowed to percolate through the filtering material, much will depend on the state of the water previous to being let on to the bed of the filter. In the most of filters at water-works the speed will be found to range from 25 feet and upwards per day, and even that is not regular in many cases; but in general, the water should not be allowed to percolate more than from 10 to 20 feet per day, passed regularly through during the whole 24 hours. To many, this speed being only from 5 to 10 inches per hour, may seem much less than there is any need for; but, taking everything into consideration, water companies, by making their filters so as to come within this limit, they would be enabled to filter all the water sent in for supply, and very materially diminish the yearly expense for cleansing.

Table showing the number of Cubic Feet and Imperial Gallons of Filtered Water One Acre of Filtering Surface is capadle of furnishing, the Water being allowed to percolate through the material from 10 *feet to* 20 *feet per day.*

Feet per Day.	Cnbic feet.		Imp. Gal.
10	435,600	=	2,722.500
11	479,160	=	2.994,750
12	522,720	=	3 267,000
13	566,280	=	3,539,250
14	609,840	=	3,811,500
15	653,400	=	4,083,750
16	696,960	=	4.356,000
17	740,520	=	4 628,250
18	784,080	=	4,900,500
19	827,640	=	5,172,750
20	871,200	=	5,445,000

Water can be filtered by passing it through the material in an upward, downward, or horizontal direction; in springs it passes along in various directions, according as it finds a passage through the different strata in its course. With artificial filters, however, the same will not apply, as in the construction of these it is necessary to take into account the process of cleansing. Upward filtration is, no doubt, the best, as the sediment, on account of its weight, tends to fall downward while the water is flowing upward; but in the cleansing of such filters there are many difficulties to contend with, as since the sediment or silt lies mostly at the bottom, the whole material requires to be taken out before the silt can be either partially or wholly removed. Horizontal or oblique filtration has similar objections. In practice the downward system has been found to suit best, as the great body of the impurities lie near the surface, and the bed of filter can be partially cleansed by scraping, as is sometimes done, or more effectually by reversing the direction of the water, as will be afterwards explained.

The material through which to filter water should be of such a nature as will remain unchanged, be imputrescent, capable of allowing the water to pass through, and which does not change in its mechanical structure—such as broken granite, trap rock, and hard gritty freestone, silicious sand, pebbly and hard gravel, clean ashes, &c.; that which is most generally employed is silicious sand and gravel; broken trap rock and freestone being only used when good coarse gravel cannot be got in sufficient quantities; they, however, suit exceedingly well for a coarse filter bed, and in many cases are even preferable to the gravel. Indeed, it has been observed, that when water passes along a bed composed of rocks of the trap, or amygdaloid species, a kind of natural filtration is effected—so much so, that even moss water is rendered in some cases comparatively pure. As to the fineness of the silicious sand, none finer than that obtained on exposed parts of the coast should be used, and it is even advisable to free that of much of its finer particles. Sometimes only the finest of the sea sand is employed; but when the filter is of large extent compared to the quantity of water required to be furnished, a good bed of coarse silicious sand, plentifully intermixed with pebbly gravel, makes a much better filter. The use of fine sand is one of the great mistakes committed in many filters at present in operation, as they always become ineffective at times when most required, besides entailing a large annual expense for cleansing.

The next important matter connected with filtration is the best construction of filters, so as to act effectually, and admit of being easily cleansed. I have already observed, that the most practical system of filtration is when the water is allowed to flow downwards through the material, as by this means the filter admits of being much easier cleansed; and further, it may now be observed, that in order to get advantage of the whole surface of filter bed, the filter should be so arranged that the water, when let on, will spread equally amongst the whole material of said bed.

In many existing filters the water is let on by various openings, and the filtered water is taken away at a level with the bottom, either by drains or by a false bottom below filtering material. In such filters the water which is let on, when the material is quite clean, will be observed to spread only a small distance from the inlet, and then disappear; but as the material becomes silted up, it gradually spreads farther on to the bed of filter, and it is only when the whole is silted up that the water spreads over the entire surface. In such a filter the actual filtering surface becomes only a part of the whole, and the coarser the material the less will that part be; and, even although the whole surface be of large extent, very slow filtration is not obtained; fine material, consequently, becomes necessary, in order to cause the water to spread over a larger part of the entire surface, as well as to prevent the impurities from passing through. Were the water, by some means or other, caused to fall on the entire surface in drops like rain, the whole would be brought at once into operation, and by having a large surface slow filtration would be obtained, and fine material become unnecessary.

That of getting the water to fall equally over the whole surface not being easily attained, especially in a large filter, the next best system is that of raising the level at which the filtered water escapes, thus causing the water, as it is let on, to be dammed back amongst the filtering material, which consequently becomes fully saturated, and is all brought more or less into operation: besides, the pressure of water, by raising the outlet, being taken off, the sand bed especially does not become so soon consolidated, as will be observed to be the case when the outlet is at the lowest part of the filter. Where such a system has been adopted the water is observed to rise in the bed of filter as the material becomes silted up, forming a thin sheet over the whole surface. During hot summer weather this thin sheet of water has a tendency to become heated and burned by the strong rays of the sun; and when there is much organic matter in the water it becomes a living mass of animalculæ, and even at some times will be found frogs, and great numbers of tadpoles. This living mass, of course, causes the sand to silt up much sooner, but generally does not affect the purity of the water when filtered, being entirely excluded by the material in filter bed; but the strong rays of a summer sun beating on the surface, by burning it, as it is termed, tends to give the water a slight taste and light brownish colour, which, although not to be detected in small, is quite perceptible in large quantities. Among bleachers this effect of the sun is a well-known fact, their pure water, by this cause, being not unfrequently rendered unfit for the required purpose. In order to avoid this, and still dam back the water, a sluice should be fixed on the outlet, by means of which the superintendent, during summer, can gradually raise or lower the level of overflow at said outlet, as he observes the water rising or falling in filter bed; by this means he can prevent the water from spreading on the surface in a thin sheet, and from being exposed and burned; and put a stop, to a great extent, to the rapid increase of animalculæ; and as for tadpoles, they could not exist. In cold weather the same precaution becomes unnecessary; in fact, at such seasons, the water is improved by being exposed in thin sheets to the influence of the sun and air.

For the cleansing of filters the system now sometimes adopted is, that of reversing the direction of the water, and conveying it away by drain, after coming to the surface, mixed with the silt. Sometimes the surface of bed is scraped—the former is, however, the better system; but on account of its not being sufficiently effectually applied, caused by the openings into drain not being properly placed, and the water sent up from below not sufficient either in quantity or pressure, in all cases where it has yet been applied its effect has been very partial, and recourse is not unfrequently had to the scraping besides; but even in such cases, although its effect in removing the silt is so deficient, still it has the tendency to improve the working of the filter bed, owing to the material being rendered more loose and open; and when often repeated, the filter bed will continue to act for a considerable time, even after it has become very much loaded with impurities. Filters for this system of cleansing are generally constructed with a false bottom, formed by brick on edge, supporting perforated tiles, the water being let into this space by means of openings or pipes when the bed is required to be cleaned.

Filters, in order to be properly cleansed by this system, should be so constructed as to admit of a large body of water being forced from below with sufficient pressure, so as to boil up and agitate the material of the filter bed, in order to free the sand of the silt; and still farther, to remove the impurities from the particles of the sand during the time that the upward current is going on, it should be well raked with a large rake; or a harrow, loaded to keep it from floating, having ropes attached, and drawn backward and forward by two men, would answer better. The effect of this raking, besides loosening the impurities, tends to spread the boiling-up of the water equally over the whole surface, and not in detached patches, as is otherwise found to be the case. By this means, the water from below, as it rises and spreads itself over the bed of filter, will gradually get loaded with impurities; and while thus loaded, were it conveyed to a drain, with a current sufficiently strong, so as to prevent these impurities from again settling on the sand, the object aimed at would be attained. In order to get a sufficient current to effect this purpose, the openings into drain should be on the same level as bed of filter, and so arranged that the run into each will be short—say about 20 feet. On drain, a sluice should be placed, so that when down the water would be prevented from getting away: it would thus keep gradually rising in the filter-bed, and if, after having acquired a depth of from 8 to 12 inches, this sluice was opened, owing to the short runs and the depth of water, there is little doubt but a strong current would be obtained, and the higher the water was allowed to rise before opening the sluice, the greater of course would be the current. In some existing filters, to cause a current, the water is let on to the surface at the same time that it is kept rushing up from below; by this system, however, it is clear there is a great loss of water, while it acts only a secondary part in the operation. But by taking all the water from below and creating a current by the system I have here mentioned, there is no waste of water, that which is used being all fully got advantage of, both for the purpose of freeing the material in filter-bed of the silt, and for creating a current to carry it, when loaded with the impurities, quickly into drain.

In order that the false bottom be enabled to stand the pressure of the water, it should be made much stronger than is generally done; the holes in tiles larger, so as to admit of the water getting freely up amongst the material; and to prevent the sand escaping from these openings, the tiles should first be covered with a layer of broken stones and gravel.

In the filtering of water, it is sometimes passed through various beds of different degrees of fineness, and sometimes only one. In cases where the water, by subsidence, can be rendered tolerably pure before being filtered, one large bed will be sufficient; but where its purity may vary much, more beds become necessary. In most cases two beds will be found quite sufficient, the one filled with a good thick bed of coarse gravel, and the other with good coarse silicious sand. If a sufficient quantity of coarse gravel cannot be easily obtained, broken granite, trap rock, or hard gritty freestone, will, as I have already observed, suit exceedingly well, continue in good working order for years, remove a large proportion of the grosser impurities, and thus render the water, before being let on to the sand bed, more equal in purity during all seasons.

In concluding these remarks on the purifying and filtering of water, I may here simply observe, that in the construction of all filters connected with waterworks for supplying large and populous towns, in order that they may be cleansed without causing the necessity of supplying unfiltered water, the filter bed should be divided into water-tight comparments, so as to admit of one part being cleansed while the others are in full operation.

BRIDGE BUILDING IN AMERICA.

At the Franklin Institute (U. S.), Mr. Solomon W. Roberts made some remarks upon bridges. He referred to the importance of economy in their construction, as large sums were often expended in such structures, when a less amount would answer the purpose. Suspension bridges, supported by iron chains or wire cables, subjected to a tensile strain, are comparatively cheap. When the material used is wrought-iron it is easy to make strong splices, but this is not the case with wood. Suspension bridges on a large scale cannot readily be built of wood, on account of the difficulty of tieing the timbers securely together and holding them fast. The bridges built by a person named Remington, about which a good deal was said in the newspapers not long ago, were wooden suspension bridges, on a small scale. It is believed that the first rude suspension bridges ever made were constructed of grape vines or some similar materials of vegetable growth. They were, of course, but of small dimensions.

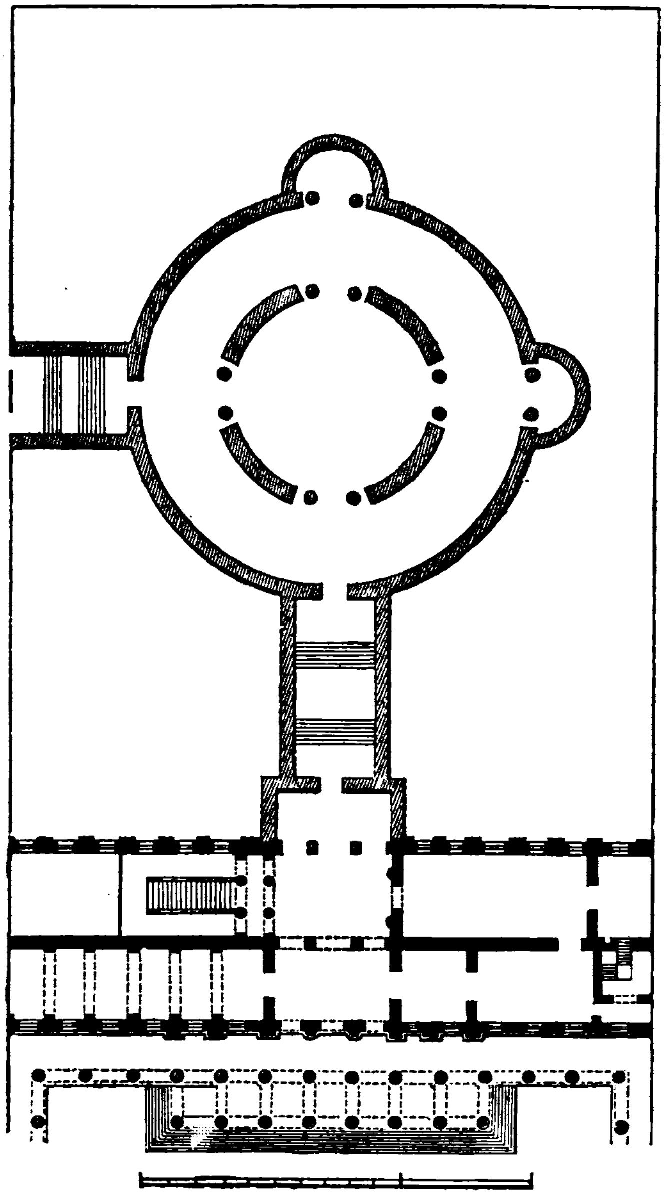
The railroads of our country abound in examples of economical bridge-building; and when we are informed that more than three millions of dollars have recently been expended in England, in building a railroad bridge about fifteen hundred feet long and one hundred feet high, it seems almost incredible. No doubt the difficulties were great, and no doubt the bridge in question is a magnificent structure: but a person accustomed to the exigencies of engineering in America shrinks from the idea of such an outlay of capital.

The wagon bridge across the Niagara river, below the Falls, is a cheap structure, the span being about seven hundred and fifty feet, and the height more than two hundred feet. It is understood that, at the same point, two able, experienced, and responsible engineers have offered to contract to build a substantial bridge for railroad trains across the most terrific torrent on the globe; and that the price asked by one was two hundred thousand dollars, and the other one hundred and ninety thousand dollars. At such prices the bridge would cost but little, if any, more than the interest for one year, at six per cent. of the cost of the tubular bridge across the Menai Strait. The cases were not alike, but they might serve to draw attention to the different circumstances under which engineering works, are executed in England and America.—*Journal of the Franklin Institute.*

The New American Gas Light.—By our advices from the United States, we learn that the excitement is still very great about Paine's system of gas-lighting by decomposing water. It is looked upon as one of the great discoveries of the age, and very strong certificates are given by those who have seen the apparatus at work, the only part kept secret being the interior disposition of the electrodes. A very strong controversy rages about Mr. Paine's abilities as an engineer, but it is certain he has long held a good standing among the practical men of his locality. Enormous sums are offered for the patent, in case he succeeds in lighting Astor House.

ANOTHER PROJECT FOR THE ENLARGEMENT OF THE BRITISH MUSEUM.

In all probability most of our readers have seen Mr. Hosking's plan for erecting a spacious rotunda in the inner quadrangle of the British Museum; and we here submit to them another, which, whether it be a better one or not, is certainly not borrowed from his, it having been produced upwards of a twelvemonth ago, by the author of the plan and elevation of a Corinthian octastyle for the façade of the Museum, published in the *Civil Engineer and Architect's Journal*, just before the present Ionic one was begun. Indeed, it is so far from being singular that the idea of providing additional and much-wanted accommodation, by erecting buildings for the purpose within the quadrangle, should have occurred to two individuals wholly unacquainted with each other's intentions, that the only surprising thing is that the architect of the Museum should have thrown away so much space; and not only space, but so much expensive work also, putting decorated stone fronts where they cannot be seen, while many parts of the exterior, which are in contact with, and come into view together with the façade, exhibit merely plain brick walls. Hardly does such contradictory treatment of what is exposed and what is concealed say much for either the economy or the judgment of Sir Robert Smirke—who being now professionally defunct, may be spoken of—that is, in his professional capacity, with as little ceremony as if he were actually dead and gone, more especially as we take him to be quite indifferent to either praise or censure.



Had no more regard been paid to appearance in the inner court than on the sides of the exterior, there might have been very little scruple to making alterations in the former; but now there must naturally be considerable reluctance on the part of the trustees to cut up and destroy—for destroyed it would be—what has had so much money expended upon it. Even should necessity at last get the better of not wholly unreasonable objections, desirable it would still be that additions made within the quadrangle should interfere as little as possible with any of the existing buildings around it. Nevertheless, Mr. Hosking proposes to remove a considerable portion of wall, both on the east and the west side of the court. Now, putting expense out of the question, it would be attended with exceedingly great inconvenience during the whole of the time it was being carried into effect, particularly in the Royal Library, which would, after all, hardly be improved by the alteration, unless further change were to be made, and its centre compartment be as much extended eastward as it would be westward, or on the side next the present quadrangle. Besides that any extension whatever of that library is not at all required; as it cannot be thrown open to the public, an immediate communication between it and the central rotunda, would, perhaps, be rather undesirable than otherwise. A similar remark applies to the other libraries forming the north range of buildings. Mr. Hosking appears, in fact, to have taken *carte blanche* for making alterations in, as well as additions to, the actual building; inasmuch as he further proposes that the present staircase—the most scenic bit in the whole interior—should be demolished, in order to obtain there an additional gallery. It is true, he provides a much more spacious staircase, in a line with the entrance-hall and his rotunda; and the new staircase might, perhaps, in point of architectural effect, be more striking than the existing one; as to which, however, we cannot pretend to speak from a mere plan, more especially as that part of the plan requires in the absence of a section, a good deal of verbal explanation to render it sufficiently intelligible. Still, great as the improvement might be, so much of both doing and undoing would be terribly expensive work, and likely very greatly to exceed what Mr. Hosking hints at as its probable cost.

Even were his design pruned down, the rotunda proposed by him would be not only so large, but so lofty a mass, that it would in a manner quite choke up the quadrangle, and greatly obstruct light, as the dome would be about sixty feet higher than the other buildings. Unless there be already more light than is found necessary, it would be expedient to keep whatever galleries might be erected within the court as low as possible, consistently with regard to good proportions. Whether that would be satisfactorily accomplished by the plan here exhibited, we leave it to others to decide after reading the explanation of it, which we begin by observing that alteration of what already exists would be confined to the entrance-hall; not, however, that it would be absolutely necessary, but it would be a comparatively trifling one in comparison with the great improvement effected by it, by rendering that hall much more striking in effect as well as symmetrical in plan, as the staircase would then occupy a central situation on the west side, instead of having, as at present, too much the look of being thrust into a corner. In the corridor leading from the hall to the new glyptotheca, or rotunda, would be two flights of steps leading down to the latter, which, in order to gain height, would be upon a lower level, by about ten feet, than the first hall. And so far from being at all objectionable, such descent, which would assume quite a different character from a staircase, would be found to contribute to picturesque variety; while the corridor itself—so to call it, might be made to serve in some degree as an additional gallery, although only one of approach, or a vestibule to the glyptotheca.

As regards the last-mentioned apartment, although it would resemble Mr. Hosking's in a general circularity of plan, it would differ essentially from that—and, indeed, from almost all other structures of a similar kind—inasmuch as it would form a double rotunda, an outer and an inner one, the former being a spacious circular gallery surrounding and enclosing the other. The germ of the idea may be found in the so-called Glyptotheca of the Colosseum in the Regent's Park, a most picturesque and tastefully-arranged interior; but which, being only part of an exhibition speculation, does not possess any of that prestige which usually awes the many into admiration—at least, into the hypocrisy of affecting to admire, merely because they are ashamed to confess their ignorance or their indifference.

The idea so derived is, however, differently treated, and further developed; a rotunda covered with a dome being substituted for the small cylindrical cove containing an enclosed staircase in the Colosseum. Though far inferior in dimensions to Mr. Hosking's, and of somewhat lower proportions—viz., 75 feet in diameter, and about 70 high, it could hardly be called small, as its diameter would be considerably greater than that of the rotunda in the Bank of England (57 feet), and of the new Coal Exchange (60 feet), or, to quote what may seem authority more to the point, the central rotunda in the Museum erected at Berlin by Schinkel, which is not more than 67 English feet in diameter. No doubt, the rotunda alone would afford very insufficient additional accommodation; but, besides that, there would be an outer ring-shaped gallery, 30 feet wide and about 25 feet high, which would form room for a considerable collection of works of sculpture on each side of it. In order to avoid interfering with, or coming into contact with the buildings on the north and east sides of the quadrangle, spacious semicircular recesses or tribunes are substituted for the oblong branches of the plan, which, on the two other sides, would connect the new building with the present ones. Those two tribunes might be covered with semi-domes, and the light might be admitted from above, either through the vertex of the concavity of the dome, or through a large arched window in the lunette or arched head of the wall forming the chord of the semicircle. In the western branch from the rotunda would be flights of steps, as in the southern one, in order to ascend to the level of the west gallery, which would there be entered, as in Mr. Hosking's plan, immediately opposite the Elgin Room; but with this difference, that the gallery itself would remain untouched, as all the alteration there required would extend to little more than breaking through the wall and forming a door *beneath* the centre window on that side; the windows being 12 feet from the floor, and the connecting vestibule between that west gallery and the circular one being somewhat lower than the latter, so that its roof (a lead flat) would clear the sill of the window,—as is now done in the new portion of that west gallery, where two doors occur beneath windows.

Such descent and ascent would, it is conceived, be not inappropriate, as marking transition and creating variety; but whether desirable or not on that account, great positive inconvenience would be avoided by placing the rotunda about ten feet below the level of the present ground-floor galleries; for, assuming about thirty feet as the height of the cylindrical walls, they would rise only eight feet higher than the sills of the windows around the quadrangle, so that they would not be visible at all through the windows from within, while the dome, being so much smaller, and consequently further off than in Mr. Hosking's plan, would occasion hardly any difference at all as to light. It may further be remarked, that although it would be no more than what attention to proportion would require, the height of Mr. H.'s rotunda would be somewhat preposterous as far as purpose was concerned, excessive height not being particularly desirable in a hall or gallery intended for the exhibition of sculpture, since sculpture can be placed only on the floor, or against the lower part of the walls. And besides that, in a room 120 feet high, even large statues would show too much like mere ornamental accessories to the architecture, so lofty and spacious a room brought into immediate propinquity with the present galleries could not fail to dwarf them, and cause them to appear diminutive in comparison with it.

Should the plan here shown, and what we have said on the subject, draw forth remarks from others, either in the shape of objections or otherwise, we may have occasion to say something further; but at present we will only add, that the plan is not to be looked upon as a matured one, but merely as a general shaping out of what might be adopted, with such modification as might be held most expedient. Perhaps it would be an improvement to make the inner rotunda still smaller—to reduce its diameter to about 60 feet, and lower it in the same proportion, so as to admit of obtaining two circular galleries around it, about 25 feet wide each, instead of a single one of 30 feet in width; that would augment accommodation for exhibiting sculpture, with very little extension of plan, and, at the same time, the height of the buildings would not require to be so high by several feet, which, under the peculiar circumstances of the locale, is a most important consideration.

Architectural Exhibition.—At the meeting of the Architectural Association, on the 26th, a subscription was handed in by a member, from "An Architect," who "regrets to find the sister art to Painting and Sculpture likely to be driven, by the unkindness of her relatives, from the portals of the Royal Academy; and in the hope, ere long, that all may share a building fully adequate to the requisitions of the three."

ON THE SUPPLY OF SPRING WATER FOR THE METROPOLIS.[*]

On the Geological Conditions which determine the Relative Value of the Water-bearing Strata of the Tertiary and Cretaceous Series, and on the probability of finding in the lower members of the latter, beneath London, fresh and large Sources of Water Supply, tending possibly to rise to heights considerably above the lower levels of the Metropolis.[†]

By Joseph Prestwich, jun., Esq., F.G.S.

The following observations are the result of inquiries connected solely with questions of pure geology. As they have, however, some bearing on a subject which is now of considerable practical importance, it has led me to give them an application which was not anticipated at the time they were made, and consequently, some of the data more immediately connected with the practical part of the question are wanting; still, the theoretical deductions may possibly be of some use. As the subject is one of great extent, I cannot, in this communication, give more than a general sketch of it. Much of the detail must necessarily be omitted.

The wells of London derive their supplies of water from three sources: 1st. From the gravel reposing upon the London clay; 2ndly. From the beds of sand and clay between the London clay and the chalk, which, in the course of the paper, will be designated as the Lower Tertiary Strata (the term "Plastic Clay Formation" being objectionable); and 3rdly. From the chalk.

Whether the beds below the chalk may not be available as sources of water supply to London, is one of the objects of this inquiry. The first of these sources is small, and does not come within the range of the present subject. The second has led from time to time to the hope that it would prove large and abundant; but from its failing, in many instances, the third has, of late especially, been much resorted to, but with variable success.

So far as London is concerned, the results yielded by the Lower Tertiary Strata and by the chalk are well known, and might be exactly determined. But in the event of its becoming necessary to inquire into the capability of any other deposit relatively to these two, it is desirable to ascertain the physical conditions under which the present supply is obtained. These are essentially geological, and have not yet been investigated. They are regulated—

1st. By the lithological character and by the thickness of the water-bearing strata, upon which depends the facility with which water can percolate through them, and their capacity, as a reservoir for water.

2ndly. By the areas over which the exposed surfaces and outcrops of these strata respectively extend, whereby the quantity of rain water, which they can receive directly, is determined.

3rdly. By the position which their outcrop occupies on the surface of the country, which governs the amount of surface water that may be absorbed, and also facilitates or prevents their receiving the drainage from off any of the adjacent lands.

4thly. By the exposed surfaces being bare, or covered by any form of drift.

5thly. By the existence of any lines of disturbance, by which the subterranean circulation of the water may be interfered with or stopped.

With regard to the first point, the lower tertiary strata vary so much in their thickness, and in their lithological character, that it is necessary to examine them over a wide range, in order to obtain any exact results, otherwise very different conclusions as to their probable water value might be arrived at.

They consist throughout of a very variable series of sands, pebbles, and mottled clays. The clays usually form distinct and separate beds, and do not blend with the sands; and, as they are not permeable, they must, in estimating the capacity of this series for water, be separated from the sands, which alone will represent the water capacity of the series. In the eastern portion of the tertiary district, the beds between the London clay and the chalk are largely developed, and sands predominate. The thickness of the series in the north-east of Kent averages about 120 feet, of which 90 to 100 feet may be sands, and the rest clays. In the north-west of Kent we find a total thickness of from 90 to 100

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[*] Read at the Royal Institute of British Architects, July 8th, 1850.

[†] Since the following Paper was written, the valuable "Report of the General Board of Health on the Supply of Water to the Metropolis," has been published. Had I been aware last autumn, when my attention was more particularly directed to this subject, by the want of geological information which seemed not unfrequently to exist in the discussions of the many plans relative to different modes of supply, that such an investigation was in progress, I probably should not have thought of engaging upon this inquiry. As it however relates to geological principles of general application, as well as to a specific branch of the question, neither of which are, I find, touched upon in the "Report," I venture to submit to the "Institution" a short statement of the principal results I have arrived at.

feet, of which about 70 are sands. In that part of the tertiary district in which London is placed, a change takes place in the condition of the lower tertiary strata. The thickness of the sands diminishes, whilst the number and thickness of the subordinate beds of clay rapidly increase. It results, that beneath London the total thickness averages about 75 feet, of which 40 only are sands, and 35 clays. At Isleworth and Twickenham the thickness of the sands beneath the London clay do not exceed 15 feet, whilst that of the associated clays amounts to 60 feet. At Claremont the sands are 10 feet, and the clays 50 feet thick. Westward from these places to the end of the tertiary district at Hungerford, the mean of a number of sections gives only 11 feet of sand, whereas the clays are 38 feet thick. This reduces the water capacity of these strata within very narrow limits. The effect also of these changes, which are particularly rapid in the district a few miles westward from London, is materially to impede the subterranean flow of water, and it is probable that little, or if any, of the water absorbed at the outcrop of the lower tertiary strata in the portions of the tertiary district, from Guildford and Maidenhead westward to Hungerford, reaches London.

The second point of inquiry refers to the superficial area occupied by the strata between the London clay and the chalk, which has apparently been generally represented as much larger than it really is. From an examination of our best geological maps, this outcrop might be estimated at about 800 square miles, whereas, it is certain that the area actually occupied by the exposed surface of these strata is under 400 square miles, and of this, a portion of nearly 200 square miles is in Kent, and is, therefore, for reasons given hereafter, useless with regard to London Artesian wells. The dimension of their exposed surface and outcrops being known, the quantity of rain received on any deposit can be readily calculated; but the quantity that would be absorbed would depend upon conditions named in the third point for inquiry. It will easily be conceived, that if a stratum crops out at the bottom of a valley, the rain falling upon it, as well as any waters derived from the drainage of the adjacent hills, will remain on the surface of its outcrop, until either absorbed by it, or else removed by the surface channels, or by evaporation. This is a common form of structure in the lower tertiaries from Croydon to Hungerford, along which line they very generally form a small and narrow valley, running parallel to the higher range of the chalk. But if the outcrop of the stratum should take place midway on the slope of a hill, then much of the rain water falling on its surface will naturally drain to the lower levels, and little or no supplies from the adjacent surfaces will be received. This is the condition which holds good, to a great extent, along the northern outcrop of the lower tertiary strata from Watford, or even from Newbury, to Hertford, and also, as far as can be judged, from Hertford to Ipswich. There are other positions of outcrop; these, however, are the two principal ones.

The fourth point is one which exercises great influence on the supply of water to the water-bearing strata. If the surface of outcrop of any deposit were always bare (the mere vegetable mould excepted) as the London clay at Primrose Hill, or the chalk downs around Brighton, then, necessarily, there would be no impediment to the passage of the surface waters into any absorbent stratum; but if the stratum should be covered by any form of drift in the shape of sand, clay, or gravel, then the passage of the surface waters would be more or less impeded, according to the tenacity and thickness of the overlying mass. In geological maps this drift is not laid down, and therefore it is sometimes conceived that the underlying strata came to or near to the surface; such is, however, not at all invariably the case. Beds of drift are very generally, but at the same time, very irregularly, dispersed all over the surface of the country. In the neighbourhood of London they are largely developed, but do not much affect the southern outcrop of the lower tertiaries. On the northern line, the outcrop being commonly on the slope of the hills, the covering of drift is very partial. In Essex and Suffolk, where the lower tertiaries frequently crop out on the summit and on the brow of the hills, a thick mass of perfectly impermeable drift clay (Boulder clay of Sir Charles Lyell) overlies them, and entirely excludes at places the surface waters.

In the fifth place, whatever may be the value of any deposit with regard to its thickness or its area of outcrop, its effective power will depend upon these conditions of thickness and area acting without interruption from the circumference to the centre; for if, from any cause, the continuity of the strata should be broken or in any way interfered with, then the other conditions, howsoever favourable, are rendered more or less inoperative, according to the amount of the disturbance. In the neighbourhood of London these causes have materially impaired the efficiency of the lower tertiary strata, as a source of water supply to London. The tertiary district is traversed by two main lines of disturbance, dividing it into four unequal areas, each of which is more or less independent one of the other. One line runs nearly east and west, and forms an irregular ridge, or small anticlinal line, passing from Cliff by Gravesend and Woolwich to New Cross, and bringing up the chalk to the surface along that portion of its range. It then proceeds, apparently, to Windsor, and thence towards Maidenhead. By the operation of this line of disturbance, the drainage of the lower tertiary strata in the north-west of Kent, where they are largely developed, is prevented from passing under the large mass of London clay spread over Essex. Southward and westward of London, as the lower tertiaries do not come to the surface, their continuity is not so completely broken by this disturbance. Another line of disturbance runs nearly due north and south, and intersects the first line at Deptford, passing apparently down the valley of the Lea, crossing the Thames, and then running up the valley of the Ravensbourne. Its effects with regard to the supply of water to London are important: it intercepts—in conjunction with the first fault—almost, if not all, the drainage water of the lower tertiaries in Kent from passing to the strata below London, and in the same way, it separates to some extent the Essex district, and prevents it from contributing any large supply of water to the division in which London is placed. There are other smaller lines of disturbance, which cannot now be noticed. From all these conditions it must be apparent that, so far from the larger portion of the outcrop of the strata between the London clay and the chalk contributing to the supply of the Artesian wells at London, the contributing surface is confined to a very small section of the whole area. The whole of Kent (except possibly for a short distance between Beckenham and Croydon) must be excluded; Essex is of but slight assistance, and the district of country from Hungerford eastward to at least about Guildford and Maidenhead, contributes probably little or nothing to the water supply beneath London.

Of the remaining portion of the area, the part from Maidenhead to Hertford is generally placed under conditions unfavourable for the absorption of the rain-water, whilst the physical structure of the district between the southern line of the outcrop and London places difficulties in the way to the free passage of water. These restrictions render it probable that, of the—say 400 square miles occupied by the lower tertiary strata, probably not more than an area of 30 square miles, if so much, can be considered as contributing to the water supply of London, which is placed at the south-east corner of the north-west division, in such a position, that, instead of its being a matter of surprise that the water value of the lower tertiary strata is not greater, it is, on the contrary, an indication of what that value would be, if a similar series of arenacious strata were placed under more favourable conditions.

As evidence of the water value of the lower tertiaries, a few cases may be briefly mentioned. In Essex, where the area of outcrop is both small and very unfavourably situated, nevertheless, from the large subterranean mass and the thickness of the strata, the supply of water is general and steady. Wells of 100 to 200 feet in depth are common, and there are many from 300 to 400 feet. The water rises in most cases to above the level of the Thames, and in quantities varying from two quarts to eight gallons per minute. It must be observed, however, that, unlike the wells in London, the Artesian wells in Essex almost invariably end in the sands below the London clay, and do not often reach the chalk. In the low marshy islands at the mouth of the Thames, these wells have of late become numerous, and have proved of the greatest value. Formerly, in dry seasons, great distress used to be experienced in these districts for want of fresh water; now, there are wells in Wallisea Island 400 feet, and in Foulness Island 450 feet deep, the water in all of which rises above the surface, and furnishes a good and steady supply in all seasons.

In Kent, the Artesian wells of Sheppy may be instanced as cases of a larger supply.

To the South of London the number of Artesian wells ending in the tertiary sands is not inconsiderable, and the supply of water is large. To allude only to one set of them, we will take those which are sunk in the Valley of the Wandle, as at Garrett, near Wandsworth, and at Tooting, where there are several such wells, 130 to 160 feet deep. Some of them have been in operation for several (10 to 25) years, and they continue to overflow at the surface at the rate of from 50 to 100 gallons per minute. At the new almshouses at Garrett, the supply from the Artesian well is 60 gallons per minute, and the water is laid on to the ground-floor of the forty-two houses, and supplies beside a small fountain in front of them.

At Kingston, Richmond, and Twickenham, the supply of water from these strata is also good. It then diminishes in proceeding westward, apparently from the thinning out of the beds of sand, and the preponderance of mottled clays in the lower tertiary strata. At Sandgate, near Chertsey, a well was sunk to the depth of 600 feet through the London clay, and ended in the mottled clays. No water was obtained. At Cobham and at Knapp-hill, near Woking, the same result was experienced. At Cobham-place, near Cobham, a well was sunk some years since through the whole thickness of the tertiary strata, commencing with the Bagshot sands, to a depth of 649 feet. The lower tertiary strata here were about 50 feet thick, of which 47 were of clay, and only about 3 to 4 feet of sand. The supply of water being small, the works were continued down further to a depth of 150 feet into the chalk; but after all, the quantity obtained was not large.

In the north-west division of the map the supply of water in the lower tertiary strata is very uncertain, and at all times small. At Norwood, in Middlesex, these strata were traversed, together with 50 feet of chalk, without finding any water; and at Hanwell, although a supply of 20 gallons of water per minute was at first obtained, yet, at the end of six years, the quantity had diminished by more than three-fourths, and other sources of supply had to be sought.

In the valley of the Lea, the Artesian wells are numerous, and tolerably well supplied. There are some at Broxbourne, several at Waltham Abbey; also at Enfield, Edmonton, and Tottenham The water rises above or near to the surface in all of them; their depth varies from 70 to 120 feet.

In London, the great number of Artesian wells has rendered it necessary to extend a large proportion of them down to the chalk, in order to obtain a better supply of water than can now be procured from the lower tertiary strata.

With regard to the much debated question as to the probable supplies of water to be expected from the chalk, there can be little doubt that a very large portion of the rain falling on any bare chalk district is absorbed at once. This is generally admitted, and is evident from the absence both of streams and also of standing waters on the surface—whether the water so absorbed passes to, and percolates freely at great depths in the chalk, or whether it remains near the surface in the upper beds, is to be determined. It is evident from the recent experiment of Professor Ansted, that the absorbent power of the chalk is very great—as much as two gallons of water per cubic foot of chalk. But so far from this property being of value as a source of free water supply, it probably favours a contrary result. For this absorbent power is, I consider, owing to a strong capillary attraction arising from the extremely fine texture of the chalk; and if such be the case, there will be a natural tendency to a rapid absorption by the upper beds of the chalk of the rain-water which falls upon its surface, but the very strength of this tendency must cause these upper beds of chalk to part with difficulty with the water so absorbed.

It will follow that it is only when the upper beds of the chalk are in a state of saturation, or when fissures allow of gravity to act on the water with a force stronger than that which solicits it by capillary attraction, that water passes deeper into the mass of the chalk. Notwithstanding these counteracting causes, as the surface of the chalk is frequently much broken and fissured, the quantity of water in its upper beds is, in many valleys, often very great. As the depth of the chalk increases, these small fissures rapidly decrease in number; but they are intersected at intervals by larger ones, which conduct part of the water to greater depths. The planes in which the flints are deposited also present unadhering surfaces and joints through which water can pass; and this, rather than a general diffusion of water in the mass, will account for the phenomenon presented in hilly chalk districts where the level of the water in wells follows nearly the surface level of the intersecting valleys; for the base of these vallies being fissured and saturated with water, this water finds probably a readier passage laterally along the planes of stratification in which the flints occur, than downwards through irregular fissures. Consequently, in sinking wells on the hills, the water is frequently found on reaching the strata which are on a level with the base of the adjacent valleys. At a certain depth in the chalk the passage of water is usually obstructed by the lower beds, known as the chalk marl, which form an almost perfectly impermeable mass, holding up the water from the upper and middle chalk, and throwing it off in numerous springs at the base of the chalk escarpment, where the angle of inward dip is not too rapid.

Unlike, therefore, strata of sand, through which water can permeate with facility in all directions, and where it will tend to take the form of large sheets co-extensive with the strata themselves, the percolation of water in the chalk is partly in the seams of bedding, and partly through fissures irregularly distributed, the direction of which can only be determined by experience. It may be compared to a mineral occurring in veins traversing a rock independently in a great measure of its stratification, and the volume and permanence of which is very uncertain; whilst, in arenaceous strata, it may be represented by the same mineral occurring in beds in any stratified deposit, of which the range is persistent and uniform, and the dimensions can be tolerably well determined beforehand.

It is also to be observed that the chalk is far from presenting a generally bare surface. On the contrary, a large portion of it in Hertfordshire and Buckinghamshire is covered by beds of a reddish drift clay, generally very tenacious and impermeable. It is from 10 to 20 feet thick, and prevents to a great extent the passage of the surface waters into the chalk. It is confined almost entirely to the summit of the hills. The valleys usually present nearly bare chalk slopes. This drift is of much less extent in Kent and Surrey.

The deepest well in the chalk is at Saffron Walden. It was bored to the depth of 1001 feet, all in chalk, and was abandoned for want of a sufficient supply of water. There are also many wells from 200 to 400 feet deep in the chalk district south of London. The very depth of these wells shows the mass not to be so water-charged as it has been frequently supposed. Water, in fact, rather percolates than permeates through the chalk. That that portion of water which finds its way through the mass of the chalk is kept up by the gault at its base, is therefore seemingly incorrect. It is more probable that it is held up almost entirely by the chalk marl.

Immediately below these latter beds is the formation called the upper greensand, which exhibits to the north and south-east of London a type so insignificant, that it would be likely to be regarded, with reference to this question, merely as a few feet of unimportant sandy beds at the base of the chalk formation itself. It must, however, be viewed over a longer range, and then it will be found to possess an importance of which the narrower limits give no indications, and to which I would call attention with regard to its value as a water bearing deposit.

At Folkstone it is only 15 feet thick, but expands to 40 or 50 feet at Merstham. At the first place it is very argillaceous, and of little value as a water-bearing stratum. It is the same at Cambridge, where it is only two or three feet thick. In Bedfordshire it is rather thicker. Taken on a line passing from Bedfordshire through London to Godstone, the lower greensand may be about 20 to 30 feet thick. Westward, however, from this line it gradually expands, slowly at first, and more rapidly afterwards, and at the same time it assumes a more distinct type, and becomes much more arenaceous and permeable. At Farnham it has attained a thickness of nearly 100 feet; near Watlington of 70 feet; at Wantage of above 100 feet; at Burbage, in the vale of Pewsey, apparently of more than 140 feet, whilst at its extremity at Devizes it is also about 140 feet thick. It therefore represents a long wedge, of which the thinner edge is beneath London, and the thicker one rises to the surface at Devizes and near Calne.

Unlike the lower tertiaries, which present such rapid changes in their lithological structure, the upper greensand presents, notwithstanding its various development, a remarkable uniformity in its structure throughout its range from the meridian of London to Devizes. It may be considered on the whole as formed of two divisions—the upper one of sands, occasionally slightly mixed with clay, and of various shades of green, generally light—the lower one of soft thin bedded or fissile, calcareous sandstone. The upper division expands more than the lower one, and, as it expands, it becomes more purely sandy and very permeable; whilst the lower division is so fissile and fissured that water can generally percolate through it with facility.

The area occupied by the outcrop of the upper greensand westward of the meridian of London is apparently about 160 square miles, of which about 110 may be effective as a source of water supply, whereas, as before mentioned, the lower tertiary possess less than 30 square miles of such surface. In their subterranean range the difference is still greater—the tertiaries spreading over an extent of about 500 square miles, and the upper greensand of

2500 square miles, in water communication beneath London. If, further, the volume of their masses, with reference only to those beds which are permeable and the area which is effective, be compared, the following is the result in round numbers, each unit representing a mass a mile square and one foot thick.

Volume of the permeable portion of the beds beneath the chalk and the London clay	10,500
Volume of the permeable portion of the upper greensand	150,000

The productive and contributing area of outcrop of the upper greensand may be considered to be four times greater, and the volume of its mass, viewed as a reservoir for water nearly ten times larger than that of the lower tertiary strata. The water in this upper greensand is everywhere held up by the underlying gault, which consist of a mass of dark grey tenacious and perfectly impermeable clay from 100 to 150 feet thick.

Below the gault is the lower greensand formation, consisting of a series of beds of loose sands and soft sandstones, with subordinate beds of clay, and groups of argillaceous strata; the sands, however, on the whole, predominate largely. As a mass, it is much more variable in mineral character than the upper greensand. It also follows a very different rule in its development; the latter thins out as it ranges eastward, whilst exactly the reverse holds good with the former. At Hythe it is, according to Dr. Fitton, 406 feet thick, whereas at Devizes it is only 13 to 20 feet thick; the decrease, however, is not gradual, for its thickness in Surrey is probably greater even than at Hythe. In Bedfordshire it may be from 250 to 300 feet thick; it gradually becomes thinner as it ranges to Norfolk on the one side, and to Oxfordshire on the other.

Without going into further details, it may be observed, that the area of outcrop of the lower greensand, with reference to the surface that might contribute to the water supply at London, appears to me not much less than 400 square miles, whilst, in its effective underground range, it is spread over an extent of about 3000 square miles, and its effective volume may be represented as a mass of 500,000 square miles, one foot thick. The great excess of these dimensions over those of the lower tertiaries need scarcely be pointed out.

The lower greensand is underlied by the Weald clay and the Kimmeridge clay, both of which are of considerable thickness (200 to 400 feet), and perfectly retentive of water. From these facts it therefore appears probable that, both with regard to areas for drainage and to capacity for water, the upper and lower greensands present conditions far more favourable than the lower tertiary strata; for their areas of outcrop are greater,—their lithological character and thickness are superior,—the position occupied by their outcrop is usually more favourable,—their exposed surfaces are generally more free from drift, and they are both, the lower greensands especially, very absorbent. These conditions determined, it remains, however, to ascertain how far they may be rendered inoperative by disturbances in the strata between their outcrop and a central point at London. The main lines of disturbance which have affected this district run nearly east and west; consequently, as the expansion of the upper greensand and its main receiving surface are to the westward of London, or parallel to these lines, the probability of the continuity of the strata being broken between Middlesex and Wiltshire is less than it would be if they were on a north and south line.

As far as my own observations go, there are apparently no faults or disturbances of a sufficient power to interrupt the underground flow of water from the outcrop of the upper greensand in Wiltshire, and more especially in Oxfordshire and Berkshire, to London. With regard to the lower greensand, the case is different. Its contributing surfaces lie northward and southward of London, and it is traversed longitudinally by some faults of considerable magnitude. The most important one runs east and west, immediately beyond the outcrop of the upper greensand and the gault at the base of the North Downs, and is of a force sufficient at places to shift the whole thickness of the lower greensand out of its true position. If this fault were continuous, and its effects equal from any point near Westerham to Farnham, then it is probable that the drainage of nearly the entire zone of exposed surface of the lower greensand—here two to five miles broad—would be intercepted by it. But lines of disturbance are rarely maintained in equal power through any great length of range; they are, as it were, intermittent; therefore, although the continuity of the lower greensand might be broken at one or more places, yet at other places it might be, and no doubt is maintained. For in a formation of so variable and arenaceous character as this, it is not necessary that each stratum should preserve its continuity. If the mass is displaced to the extent of 100 to 200 feet, provided strata of a loose sandy nature are brought into juxtaposition on the opposite sides of the fault, that will be sufficient to keep up the circulation of water from one side of the disturbance to the other, and the waters dammed back in those parts where the disturbance is greater, and the continuity completely destroyed, will pass round through such points of communication. Nevertheless, there is no doubt that the water-value of strata so affected must be lessened, and for this allowance has been made. On the zone of outcrop to the north of London there seems to be but few disturbances, or, at all events, not any of sufficient magnitude to produce great interference, except westward beyond Abingdon, where the lower greensand is entirely cut off by a fault. The previous calculations therefore only refer to the districts from Wallingford and Biggleswade, and from Farnham to Maidstone. But it is to be observed also that the lines of disturbance which so materially affect the comparatively thin and not deep-seated beds of the lower tertiary strata would be of little consequence in the deep-seated greensands, where the water-level is so far above the level of the disturbed strata. It is therefore, I think, probable that the upper and lower greensands constitute two important zones of water-bearing strata underneath London, and it next becomes a question to determine at what depth they may be met with.

The thickness of the chalk has been very variously estimated, but there are good geological grounds for presuming that the chalk underneath London is not above 600 to 700 feet thick; if, therefore, a point be taken where the tertiary strata are not above 200 feet thick, it is probable that the upper greensand would be reached at a depth not exceeding at a maximum 1000 feet, and the lower greensand at 1200 feet. Supposing this to be the case, then, as the outcrop of the upper greensand above Trinity high-watermark at London is 360 feet southward at Merstham, and 135 ft. northward beyond Hitchin; and as, with few exceptions, it continues to maintain a high and increasing level from these points westward to Calne and Devizes, where it reaches an elevation of about 450 feet; it follows that a supply of water from this source at London would probably rise to a height of from 100 to 150 feet above the level of the Thames at London. The outcrop of the lower greensand varies from 100 to 300 feet above the same level; and, as the distance of its contributing areas of outcrop from London is much less than those of the upper greensand, it is probable that its waters might rise to a height of 80 to 100 feet, or more, above the level of the Thames.

In conclusion, although the supply of water obtained from the lower tertiary strata at and around London is confessedly inadequate to the supply of a large town, yet it is, as a local supply, in many cases, of considerable value. If, therefore, with an area of outcrop of such limited extent, and a capacity of such moderate volume, the lower tertiary strata nevertheless are of not inconsiderable value as regards their water supply, then it is probable that, with dimensions in every respect so much greater, and under conditions generally so much more favourable, the upper greensand, and the lower greensand more especially, must possess a water value very considerably greater; and there appears to me to be no reason why, in the case of the upper greensand, the downs and valleys of Wiltshire and the plains of Oxfordshire and Berkshire, should not contribute their contingent to a supply of water at London, or why even a very much larger supply, amounting possibly to as much as 50,000,000 of gallons daily, if needed, should not be furnished by the lower greensand of the hills of Kent, Surrey, Buckinghamshire, and Bedfordshire. The first source of supply would be doubtless purer and better; but the latter would be more abundant, and more generally available for all ordinary purposes requiring large supplies, while, from its being naturally at a high pressure, it might be applicable, not only to sanitary improvements, but also to the ornament and convenience of the metropolis.

Monsieur D'Archiac, who has paid great attention to the subject of the water-bearing strata of the tertiary and cretaceous series of France, confirms, as the result of his experience, the rule laid down upon perfectly independent grounds by the Abbe Paramelle, in his 'Observations on Springs,' viz., "That the underground currents of water follow the same law as those which flow on the surface." This is a natural consequence of the physical structure which determines the water-sheds of a country. Applied to the case before us, it would corroborate the views advanced in this paper; for as the Thames and its tributaries effect the surface-drainage of the tertiary and cretaceous districts around London, so would the circulation of water, in the subterranean range of the lower cretaceous strata, have a tendency to follow underground a direction corresponding to that in which it flows on the surface, and would indicate that the position of London, with reference to the probability of meeting with such sources of supply, is extremely favourable.

There are many other points I could have wished to notice, such as the fall of rain on the surfaces of the different water-bearing strata—the quantity of free water which the masses will hold, &c., but which the limits of this paper will not allow me to enter upon. Should the general conclusions be correct, and should there exist beneath London two large and important, and hitherto untouched sources of water supply, it then becomes a question how far such sources are available, and what may prove to be the quality of the water. It was not my intention, nor do I feel competent, to go beyond the theoretical part of the inquiry, the impartial discussion of which was the sole object I had in view; there are, however, a few questions of practice, and an analogous case, so strongly in point, that I cannot help making a few observations on them. The great difficulty experienced in sinking Artesian wells in London has arisen from the circumstance of the water not rising to within many feet (60 to 100) of the surface, in consequence of which it has been necessary to sink shafts through the London clay, as well as through the loose sands and clay below it; a work frequently attended with great difficulty and expense. The chalk once reached, the operation of boring to greater depths has been comparatively easy. As it is, however, probable that the water from the greensands would rise, generally, to above the surface, the whole depth could be bored, and the great expense of sinking the shafts would be avoided. The case in point to which I would refer is the Artesian well at Calais; it presents conditions so strikingly similar to those which would probably be found to exist at London, that I think it may be viewed, although unsuccessful* in furnishing a supply of water, as a fair criterion of the difficulty and expense of a like operation here.

The tertiary strata presented, probably, even greater impediments than they would at London. The first 80 feet consisted of gravel and loose wet sands; then followed a succession of clays, sands, and pebble beds, of a thickness of 161 feet—the larger part being sands. These beds belong to the lower tertiary series. Below them is the chalk, through the entire thickness of which the bore was continued 762 feet. Then followed 3 feet of a stratum, which may be the equivalent of the upper greensands, and then 24 feet of gault clay, and finally, 17 feet of hard greensand. The total depth at this point was 1047 feet. So far the work, which was begun in 1842, had been two years and-a-half in progress, but would have been completed in much less time had it not been for delays in the arrival of the necessary apparatus. The size and number of the flint pebbles, and the hardness of the chalk, also caused delay, by breaking the instruments several times. The total expense, up to this time, amounted to 48,500 francs, apart from the cost of the temporary tubes, which came to 18,471 francs. Had the work been successful, the engineer, M. Mulot, would have been entitled to the latter, together with a further sum of 10,000 francs, consequently, the expense of the work necessary to have obtained the hope for supply of water at this depth would not have exceeded 3000*l.* A further sum of 12,000 francs was afterwards voted, and the works were carried, still without success, to a total depth of 1150 feet—a depth, I believe, sufficient to reach the lower greensand at London, while the depth to which the well was first sunk would here, I think, more than suffice to reach the upper greensand. The depth of the Artesian well at Grenelle, in Paris, is nearly 1800 feet, and the yield of water about 1,000,000 of gallons per 24 hours. It rises about 120 feet above the surface, and the water-bearing strata crop out in the country beyond Troyes at an elevation of about 300 to 350 feet above the surface level of this well.

There would, therefore, I conceive, be no practical difficulty in boring through the tertiary strata and the chalk to the upper greensand beneath London. The thinness of the latter at this point renders it, of course, uncertain how far its supply of water may be interfered with by causes which have escaped notice. Should any unforeseen causes occur, which, however, I do not anticipate, then it would be necessary to continue the work deeper, so as to reach the lower greensand, which, as the upper greensand is close and compact, and underlied by clay only, would not be attended with any unusual difficulty. The great thickness and extent of exposed surface of this formation renders the chance of success much greater than with the upper greensand.

With regard to the quality of the water, the uniform character and mixed calcareous and silicious structure of the upper greensand are favourable for a supply as good, or probably rather better, than that from the chalk—probably not quite so hard. With regard to the lower greensand, although it consists chiefly of pure silicious sands, still many of the beds are ferruginous, and others of very variable mineral character; the quality of the water which would be obtained from this source would therefore be rather uncertain. Admitting that it should not be fit for domestic purposes, still it would be free from organic impurities—it would possess a uniform temperature of from 68° to 70°. (The water of the Grenelle well contains 14 grammes of solid residue in 100 litres, whilst the same quantity of Seine water contains 17½ grammes.)

For the purposes of stand-pipes for cleansing the streets and courts for safety against fires, for public fountains, and ornamental waters (such as the Serpentine), for irrigation and for baths, I believe that a very large and important auxiliary supply might thus be obtained. Even on a limited application, eight or ten wells of this description, yielding from 6,000,000 to 10,000,000 gallons daily, sunk in different parts of London, each with a limited distributory apparatus attached to itself as a centre, would probably constitute, to a certain extent, an efficient and economical mode of supply for this object, and might prove a measure of public utility and advantage.

LATERAL STRENGTH OF STONE.

SIR—Experiments on the lateral strength of wood have already been made in abundance; but on the lateral strength of stone—that is, what weight is required to break it when supported at each end, and the weight laid on the middle of its length, I am not aware of any experiments on record.

This void is the more remarkable, considering the numerous applications of stone supported at the ends and loaded in the middle—especially in Grecian architecture—for entablatures, lintels, &c.; and in stairs, landings, balconies, platforms, &c., &c. The following experiments on a variety of stone and slate were made at the time the Chester General Railway Station was constructed, in March 1848. If you think them worth a place in your *Journal*, chiefly with a view to engage others to pursue the subject, I beg to put them at your disposal, and vouch for the greatest care having been employed to insure their accuracy:—

Bangor Slate.

Entire Length.		Distance between the Bearings.		Breadth of Slate or Stone.		Depth or Thickness.		Weight of Slate or Stone.	Breaking Weight.	Deflection.
ft.	in.	ft.	in.	ft.	in.	ft.	in.	lb.	lb.	in.
3	3	3	0	0	11¾	0	1¾	76·50	3794·75	0 3/16
3	3¼	3	0	1	0	0	1 3/16	77·50	4341·50	0 3/16
3	3¼	3	0	1	0	0	1 3/16	77·00	3583·00	0 3/16
3	3⅛	3	0	0	11¾	0	1⅝	78·00	3770·00	0 3/16
Llangollen Slate.										
3	3	3	0	1	0¼	0	2	96·75	1980·00	0 ⅛
3	3	3	0	1	0¼	0	2	96·75	2352·00	0 ⅛
3	3	3	0	1	0¼	0	2	97·75	2922·00	0 3/16
3	3	3	0	1	0¼	0	2⅛	101·25	3770·00	0 3/16
Stourton Stone.										
3	2½	3	0	1	0	0	4	168·00	591·00	
Wingerworth Stone.										
3	3	3	0	1	0	0	4		3784·75	
3	3	3	0	1	0	0	4		2773·50	
Red Stone Quarry, South side of River Dee, Old Chester Bridge.										
3	1¼	3	0	1	0⅛	0	4	158·00	921·00	0 ⅛
3	3	3	0	1	0	0	4	154·00	1302·00	0 1/16
Yorkshire Flags.										
3	1¼	3	0	1	0	0	2	75·00	1021·00	0 ⅛
3	1¼	3	0	1	0	0	2	78·00	920·00	0 ⅛

Note.—The Bangor Slate in each experiment was fractured straight across on top, and splintered underneath; the Llangollen Slate splintered; the Wingerworth Stone fractured nearly straight and square across; and that from the Red Stone Quarry fractured straight.

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* This is probably caused by a *fault*, of which there are apparently indications a few miles to the south of Calais. Without a more important knowledge of the district, I can, however, only hazard this opinion.

The machinery for the experiments consisted of two bars of malleable iron for supports. These were reduced to an acute angle on their upper edge, and perfectly straight longitudinally; both were fixed in blocks of wood, laid on two stone walls about 5 feet high, thus leaving enough of space for applying the weights below. These bars were laid level in the direction of their length, and level with each other; exactly parallel, and placed, as correctly as could be measured, 3 feet apart, from the angle of the upper edge of the one to that of the other. The stone or slate having been previously dressed to a uniform breadth and thickness throughout, and 3 ft. 3 in. in length, were successively—when experimented—laid on the iron bearings crossing them at right angles, and equidistant from the ends. Another iron bar, having its under-edge dressed to an acute angle and straight in its length, was laid perfectly square across the middle of the stone or slate under the experiment. This third bar of iron projected over the stone or slate, sufficient to suspend therefrom, at each end, an iron triangular frame. The bases of the triangles being horizontal and parallel to each other, served to support the weight applied to break the stone; which weight consisted of bars of iron, laid on one by one, with great caution, so as not to communicate a concussion to the weight. No steelyard or levers of any kind were used, so that the quantity of iron laid on, including the triangular frame and cross-bar being all weighed, gave the nett weight required to break the stone or slate.

Seacombe, May 30th, 1850. William Stewart.

RAILWAY POINTS AND CROSSINGS.*

Mr. Campbell, the resident engineer of the Edinburgh and Bathgate Railway, has invented some improvements in railway points and crossings, and in setting of the rails in the chairs, which have been adopted with success on the above railway. The annexed engravings show the improved points and crossings, as well as the common and the patent make.

FIG.1

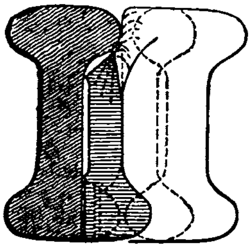


FIG.2

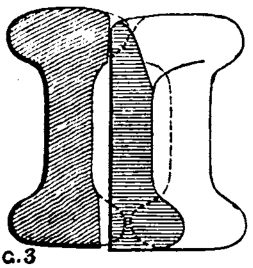


FIG.3

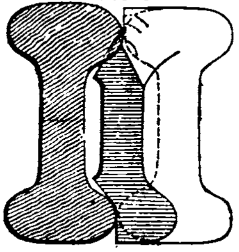
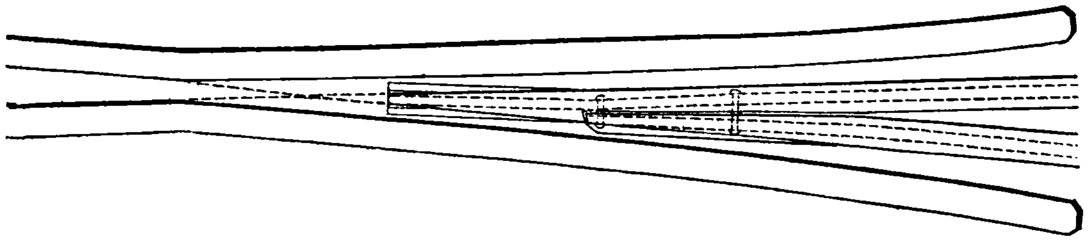


Fig. 1 is a section of the improved switch, drawn to a fourth of the full size, at the points of the switches. It is on the bottom side the same as the common switch, while on the top it resembles the patent switch; but it is simple and equally as efficient, and will stand more work. The bearing surface is neither notched nor undercut, the inside of the top of the switch being bent with a twist so as to pass under the top flange of the stock rail. The top of the switch not being mitred into the underside of the bearing surface of the stock rail, it is not liable to be locked by the barbing over of the stock from the pressure of the wheels, as frequently happens with the patent switch and others which resemble it in cutting under the top flange of the stock. In Mr. Campbell's improved switch, part of the *under* flange of the stock is cut away, which allows a broader and steadier base for the switch, and at the same time stones do not so readily rest between and prevent the shutting of the switch.

FIG.6



Mr. Campbell was not aware of anything having been done to meet the tear and wear of the crossing point, notwithstanding the weight of the engines in use. Any contrivance for the main road must be very secure; but at stations where there is much traffic, while the transit is slow, the wheels might be assisted over the interval at the crossing point by a piece of iron keyed between the rails, having its surface one inch below the top of the rail, and tapering down at each end, on which the flange of the wheel would run till the face again touched the rail, and so be prevented from falling, as it does, off the steeled point with a blow on the knee of the wing rail, which is the point that gives way. This is similar to what is done at the crossing of the bars on a turntable. The chair is laid level on the sleeper, but the seat of the rail is inclined 1 in 15 in the chair, as shown in fig. 4, so as to give the rail an equal cant its whole length, to meet the cone of the wheel. The inside jaw of the joint chair should fit close up under the flange of the rail, but the intermediate chairs should not rise quite so high,

FIG.4

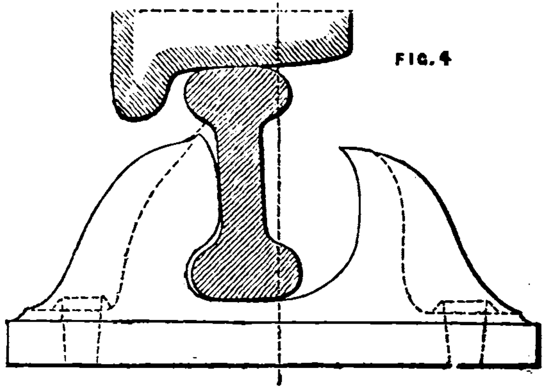
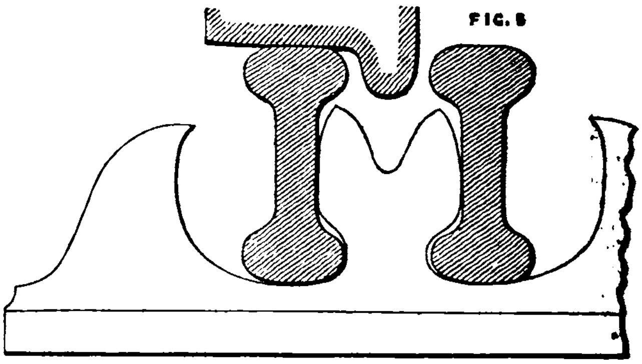


FIG.5



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* The description is from a paper read by Mr. Campbell, at the Royal Scottish Society, 25th March, 1850.

and be slightly rounded on the inner face to allow the rail to adjust itself to the joints, which are first keyed and spiked firm.

Fig. 2 shows a section of the common switch, which possesses the advantage of a straight face and continuous bearing surface; but in consequence of it consisting of two parts, is much less durable at the point than the improved switch.

Fig. 3 is a section of the patent switch.

Fig. 4 is a section showing the cant of the rail in the chair.

Fig. 5 is a section of a check rail chair.

Fig. 6 is a plan of a crossing point.

FLOATING OF THE FOURTH AND LAST TUBE OF THE BRITANNIA BRIDGE.

The floating of the fourth and last tube, which may be said to complete this magnificent structure, came off on Thursday morning, the 25th ult., at 9 o'clock, witb success.

The interest that has throughout been associated with these great engineering performances was probably heightened on the present occasion from the fact of its being the last great launching operation of the kind likely to occur in this country, and accordingly, the concourse of people present from all parts was estimated to be not far short of the thousands who thronged the Straits on the occasion of floating the first tube.

At the above hour Mr. Stephenson, M.P., Captain Claxton, Mr. Edwin Clarke, Mr. Bidder, Mr. C. H. Wild, Mr. Ricardo, M.P., Mr. Lee, C.E., Mr. Borthwick, C.E, and others, took their stations on the top of the tube, which, amid the cheers of the multitude, gradually, as the tide came up, rose upon its cradle of pontoons. The men at the mooring-chains and capstans then, in obedience to the various signalings and coloured flags, plied away at their posts, until at three minutes past 9, the huge mass, when released from its moorings, moved out into mid-stream, where under the control of the vast and intricate tackle, it made its way for full 40 minutes, until in the space of another ten, and after varions uice evolutions, it came home and was safely deposited, amid artillery and cheers, on the projecting plinths of the towers. The tide taken at starting was 12 ft. 8 in., and it gradually rose until it reached a maximum of 17ft. The total distance travelled over from the starting point on the Carnarvonshire coast to the base of the towers was upwards of 300 yards. At about four minutes past 10, just as the operation was completed, the tide turned and it was high water at 32 m. past 10. The length of the tube floated was 470 feet; its weight, 1690 tons; the number of pontoons, 8; their aggregate burden, 2750 tons; the number of men engaged in the floating, 685. During the operation, the spectators were permitted to stand upon the top of the tube already in use, and which was covered with them from one end to the other. The completion of the bridge will cause the Chester and Holyhead Company to dispense witb nearly 1000 workmen, who since the commencement of the works, with their wives and families, have been in constant occupation. The hydraulic presses are on the towers and will commence lifting almost immediately. The tube that has been in daily use since the 18th of March last, has presented to the most careful observation no change or alteration up to this time. The deflection found to be caused by the passage of ordinary trains daily is two-tenths of an inch, and some extreme heavy coal trains have deflected it as much as half-an-inch. The effect of joining the several tubes together, and lowering the opposite end, has been to raise them four inches, so that the most heavy trains do not counteract more than one-eighth of the advantage that was gained by this process.

An early day in November next is officially announced by the engineers as the period for the consolidation and complete public opening of the bridge.

NOTES OF THE MONTH.

Exhibition Building.—Another estimate has been sent, by another party, to the Royal Commission for the Exhibition of 1851, offering to construct a building similar in dimensions to that of Mr. Paxton, but in iron, in place of glass, for the sum of 40,000*l.*, the material to be returned to the contractor. If this offer be accepted, there will remain out of the 64,000*l.* subscribed a balance in hand of 24,000*l.* for other expenses of the Exhibition. Whereas, the estimate of the glass building being 85,000*l.*, will leave a deficiency of 21,000*l.*; and if to that sum we add 24,000*l.* for other expenses, it will make in all a deficiency of 45,000*l.* Moreover, the risk will be avoided of the calico, intended to cover the glass building, being fired with squibs or crackers, or by some accidental sparks from the neighbouring chimneys, which, in all probability, would soon break the glass and fire the goods within,—and thus terminate the Exhibition with as much confusion as it has begun.

A model of London has been made for the Exhibition of 1851, on a scale of eight inches to the mile, and containing in all ninety-six square feet. We understand that it exhibits the exact situation of all the public buildings, churches, bridges, railways, &c., with the Thames from Battersea to Rotherhithe, and shows the different elevations of the streets.

Death of Robert Stevenson, Esq., C.E.—It is with extreme regret we have to announce the death of Mr. Stevenson, the civil engineer, an event which took place on Friday, the 13th inst. Mr Robert Stevenson, had reached the advanced age of 78. The contemporary of Telford, Rennie and Stephenson (of England), needs no biography beyond an enumeration of his works. Mr Stevenson, it will be remembered, was the sole designer and executor of the celebrated Bell Rock Lighthouse, which is in itself a monument of ingenuity and industry. Sir Walter Scott, in his diary, mentions Mr. Stevenson in terms of admiration, and his impromptu in the album of the Bell Rock Lighthouse is well known. Mr. Stevenson first hronght into notice the superiority of malleable iron rails for railways over the old cast-iron, a fact which has been fully acknowledged. He also surveyed the line between Edinburgh and Glasgow, and though his plau was not adopted, it was much admired. The coast of Scotland, however, is the place where the labours of Mr. Stevenson are principally to be seen. Not a harbour, rock, nor island, but bears evidence of his indefatigable industry, and it is incalculable to think of the amount of life and property which by his exertions, have been saved. In matters relating to the construction of harbours, docks, or breakwater, he was generally consulted as an authority; and received, as a mark of respect and admiration, a gold medal from the late King of the Netherlands. We may mention that in private life nothing could excel the amiability and good heartedness of Mr. Stevenson. His courtesy on all occasions was such as to render blm popular with all who desired access to his presence.—*Scottish Railway Gazette.*

The Great Bull from Nineveh.—The lovers of art will be pleased to hear that the Great Bull and upwards of 100 tons of sculpture, excavated by our enterprising countryman, Dr. Layard, are now on their way to England, and may be expected in the course of September. In addition to the Elgin, Phigalian, Lycian, and Boodroom marbles, our museum will soon be enriched with a magnificent series of Assyrian sculptures. It is said at Nineveh that the French Government are determined to excel us in the exhibition of Assyrian works of art in order to compensate the comparative deficiency which the Louvre is obliged to acknowledge as to the treasures it possesses in the other great catalogues, and that large sums have been accordingly voted for the expenses of excavation. A drawing which represents the shipping of the sculpture has been just brought over by one of the Messrs. Lynch, of Bagdad, who has been with Dr. Layard exploring the remains of Nineveh. It represents the action of placing the great Bull on board the Apprentice, at Morghill, on the right bank of the Euphrates, about three miles above the old city of Bussorah. This place long formed the country residence of Colonel Taylor, lately the political agent of this country at Bagdad and Bussorah, and is now rented by Messrs. Stephen Lynch and Co., to the Hon. East India Company, as a depot for their vessels on the Euphrates. Alongside the Apprentice is the Nicotris steamer, under the command of Captain Jones, I.N., whose influence with the natives is most powerful, and to whose assistance the success in effecting the difficult operation on the muddy and deserted banks of the Euphrates is in a great measure attributable. The Apprentice was sent out from this country by Mr. Alderman Finnis, at the instance of the trustees of the British Museum, and to that gentleman and his nephews, Messrs. Lynch, the public are indebted for a periodical communication between the Thames and the Euphrates. Another vessel belonging to the alderman is, we understand, about leaving London, and it is hoped that she may in like manner return home laden with the monuments and trophies of what we had been too apt to regard as the semi-fabulous metropolis of the ancient world.

Isthmus of Panama.—The news from the Isthmus is unfavourable to the early construction of the railroad between Chagres and Panama. Impediments had occurred which were never contemplated, and, if the work is not entirely abandoned—as it is supposed it must be—it will at all events be many years before it can be completed, at a cost, too, compared with which, the original estimates are trifling. Such is the publicly avowed opinion of those who are best informed on the subject. Important modifications of the contract had been obtained from the Congress of New Grenada, among which is the conclusive privilege of constructing a plank or wagon road for temporary purposes. The immediate opening, however, of the less fatiguing, less distant, and perfectly salubrious route throug Nicaragua by the Atlantic and Pacific Ship Canal Company, will undoubtedly do away with the necessity even of this substitue for a railroad, by monopolising, as it must do, the whole traffic of the Isthmus.

Gas.—There are now in England and Wales 560 proprietary gas-works, and in Ireland and Scotland 170. Besides these there are thirty-three which belong to private individuals, and twelve the property of municipal bodies or parish officers: in all, 775 distinct establishments for the manufacture and sale of gas. In these works a capital of 10,500,000 is said to be invested. The quantity of gas annually produced is about 9000,000,000 cubic feet, and the coal consumed in making it weighs 1,125,000 tons. The number of persons employed in its production is about 20,000; and probably an equal number finds employment in the preparatory work in the mines, ironworks and other processes connected with it. After allowing for waste and leakage, the quantity of gas actually sold to the public, in the year, is about 7200,000,000 feet, producing a light equal to what would be given out by 32,133,640 gallons of sperm oil; which at eight shillings a gallon would cost the consumers 13,253,456*l.* The gas itself is charged by the companies about 1,620,000*l.*

White Paint.—The French chymists have discovered a process by which a white paint is obtained from zinc, of a character eminently fitted for every purpose for which white lead has hitherto been applied. It would appear that during the manufacture of the zinc, a stream of atmospheric air is constantly made to disseminate itself throughout the preparation; and by this simple process the many objectionable characteristics of the zinc paint, in general, are effectually removed. The French government have awarded high honours to the discoverers, and have extended the more solid advantages of direct encouragement to the patent—the poisonous white lead having been denounced in all the public works, and the white zinc paint under notice generally adopted; nor has this been done without those necessary tests of excellence which should always mark a course which is intended as a general example. This paint is perfectly innocent, both to the artizan and to those inhabiting places covered by it. For iron it proves an immediate preservative, entering at once into the pores of the metal and producing an amalgam. The gentlemen deputed to give it the most extended publicity in this country are the Messrs. Hubbucks, opposite the London Docks, who have already made arrangements for its manufacture and economical distribution. It may be added that its application has a decided sanitary effect, and disinfects every substance upon which it is laid.

Protection of Iron from Oxidation.—The following report "On the Method employed by M. Paris, for Protecting Iron from Oxidation," has been presented by M. Ebelmen to the French Society of Arts:—Various means have hitherto been employed for the purpose of protecting iron from the destructive action of air and moisture; up to the present time, the application of a thin layer of another metal to the surface of the iron has been the basis of all these methods of preservation; and tin, lead, and zinc, have all been employed for this purpose. Iron can be preserved from oxidation and destruction by covering its surface with a vitreous substance, and it is this process which M. Paris has adopted in the preparation of the various objects submitted to the notice of the Society: these objects consist of various utensils employed in domestic economy—iron pipes, chemical apparatus, sheet-iron for roofing, &c. Your committee of chemical arts have examined these specimens, with a view to ascertain whether the iron prepared by the process of M. Paris presents those conditions of solidity, strength, and durability announced by the author of the discovery. The composition which M. Paris applies to the iron is a real transparent glass, which allows the colour of the metal to be seen through it. The composition is spread with regularity, and leaves no portion of the metal uncovered—a very important circumstance. It does not peel off or crack when exposed to the direct action of the fire. Three times have we heated to redness the bottom of a prepared iron capsule, until the composition has become quite soft, and then plunged it into cold water; it was only in the third experiment that some small portions of the glaze, were detached from the metal in small scales. No fissure or crack was produced during this trial. Hot and concentrated acids scarcely have the slightest action on this unoxidisible iron. Such, however, is not the case with alkaline liquors. We boiled for about two hours a weak solution of a potash in one of the prepared capsules; the resulting liquor contained silex and boracic acid in appreciable quantities. We are of opinion that the unoxidisible iron of M. Paris offers the conditions of resistance and unalterability announced by the inventor; consequently, this new product appears to us susceptible of several very advantageous applications.

Ivory Engraving.—The process used to cover ivory with ornaments and designs in black, consists in engraving in the ivory itself, and then filling in the designs with a black hard varnish. To obtain finer and more regular designs, the ivory is to be covered with the common ground, and by means of the point the designs are engraved upon it. They are then eaten in by a solution formed as follows:—Fine silver, 6 parts; nitric acid, 30 parts; distilled water, 125 parts (by weight). At the end of a half-hour, according to the depth to be given, it is to be washed with distilled water, and dried with bibulous paper. The design is then exposed for an hour to the solar light, and the layer of wax is removed by essence of turpentine. The design has then a black colour or a dark brown, which blackens entirely at the end of one or two days. Other colours may be produced, by replacing the solution of nitrate of silver by a solution of gold or platina in aqua regia, or of copper in nitric acid.

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM JUNE 20, TO JULY 25, 1850.

Six Months allowed for Enrolment, unless otherwise expressed.

William Saunders, of the firm of Randell and Saunders, of Bath, Somerset, stone merchants, for improvements in sawing and sawing machinery.—June 20.

John Hunt, of Stratford, Essex, engineer, for improvements in forming and moulding plastic substances, and the machinery and apparatus employed therein.—June 20.

Robert Andrew Macfie, of Liverpool, sugar refiner, for improvements in manufacturing, refining, and preparing sugar, also improvements in manufacturing and treating animal charcoal—June 24.

Henry Stephens, of Stamford-street, Blackfriars-road, writing fluid manufacturer, and Edwyn Wylder, of Paddington, Middlesex, mechanist, for certain improvements in ever-pointed pencils, pens, and penholders.—June 24.

William Laird, of Liverpool, merchant, for improvements in life boats, and in apparatus for filtering and purifying water. (A communication.)—June 24.

Joshua Vickerman Binns, of Lockwood, near Huddersfield, York, mechanic, for improvements in piecing wool cardings, and in a machine called a piecing-machine—June 24.

Edward Mitchell, of Great Sutton-street, Clerkenwell, gentleman, for improvements in fastenings for articles used for writing and drawing and other purposes, and improvements in articles to be used for writing and drawing.—June 24.

John Percy, of Birmingham, doctor of medicine, and Henry Wiggin, of the same place, manufacturer, for a new metallic alloy, or new metallic alloys.—June 24.

Thomas Fulljames, of Old Kent-road, gentleman, for certain improvements in machinery or apparatus for raising, lowering, and moving weights or other heavy bodies.—June 26.

James Forster, of Liverpool, merchant, for improvements in filtering water and other liquids.—June 27.

Joseph Foot, of Spital-square, Middlesex, for improvements in boilers.—June 27.

William Lancaster, of New Bond-street, Middlesex, gunmaker, for improvements in the manufacture of fire arms and cannon, and of percussion tubes.—July 3.

John Coope Haddan, of Bloomsbury-square, Middlesex, civil engineer, for improvements in the construction of carriages and of wheels, and in brickwork.—July 3.

Francis Edward Colegrave, of Brighton, Esq., for improvements in the valves of steam and other engines in causing the driving wheels of locomotive engines to bite the rails, and also in supplying water to steam boilers.—July 3.

Charles Phillips, of Bristol, engineer, for improvements in apparatus or machinery for cutting turnips and other similar substances as food for cattle.—July 3.

Richard Hornsby, of Spittlegate Grantham, Lincoln, agricultural implement manufacturer, for improvements in machinery for sowing corn and seeds, and in depositing manure in thrashing machines, in machines for depositing or winnowing corn, and in steam engines and boilers for agricultural purposes.—July 3.

James Thomson, of Glasgow, civil engineer, for improvements in hydraulic machinery, and in steam-engines.—July 3.

Richard Winter, of New Cross, Kent, gentleman, for improvements in metallic vessels for measuring and holding liquids.—July 3.

James Ward Hoby, of Blackheath, engineer, for certain improvements in the construction of parts of the permanent way of railways, and in shaping iron.—July 3.

Paul Rapsey Hodge, civil and mechanical engineer, of Adam-street, Adelphi, for improvements in certain descriptions of steam-engines, and in the apparatus and management for cultivating and manuring the soil, and in treating the produce thereof. (A communication.)—July 3.

Wakefield Pim, of Kingston-upon-Hull, engine and boiler maker, for certain improvements in the construction of the boilers and funnels of steam-engines.—July 3.

Charles Starr, of New York, United States of America, for improvements in bookbinding.—July 3.

James Kingsford, of Essex-street, Strand, Esq., for improvements in refrigerating and freezing.—July 8.

Weston Tuxford, of Boston, Lincoln, for improvements in machinery for crushing or pressing land, and for shaking straw; also improvements in applying steam-power to agricultural machinery.—July 4.

Henry Pratt, of New Bond-street, Middlesex, camp equipage manufacturer, for improvements in the construction of portmanteaus and travelling trunks.—July 9.

Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for improvements in the preparation and manufacture of caoutchouc or india-rubber.—July 9.

Robert Rumney Crawford, of Warden Paper Mill, Northumberland, paper maker, for an improvement in drying paper.—July 10.

Jacob Connop, of Hyde-park, Middlesex, gentleman, for improvements in melting, moulding, and casting sand, earth, and argillaceous substances, for paving, building, and various other useful purposes.—July 10.

James Hill, of Stalybridge, Chester, cotton spinner, for improvements in or applicable to certain machines for preparing cotton, wool, and other fibrous substances for spinning and doubling.—July 15.

Tempest Booth, of Ardwick, Lancaster, gun manufacturer, for certain improvements in the method of and apparatus for obtaining and applying motive power.—July 15.

Edward N. Smith, of West Brookfield, Massachusetts, in the United States of North America, for a machine to fold paper.—July 17.

Edward John Dent, of the Strand, Middlesex, chronometer-maker, for improvements in compasses for navigation, surveying, and similar purposes.—July 17.

William Herbert Gossage, of Stoke Prior, Worcester, chemist, for improvements in obtaining certain metals from some compounds containing such metals, and in obtaining other products by the use of certain compounds containing metals.—July 17.

Jean Jules Varillat, of Rouen, France, manufacturing chemist, for improvements in the extraction and preparation of colouring, tanning, and saccharine matters from various vegetable substances, and in the apparatus to be employed therein.—July 17.

John Melville, of Upper Harley-street, Middlesex, Esq., for certain improvements in the construction of railways and locomotive engines and carriages.—July 17.

Henrietta Brown, of Long-lane, Bermondsey, widow and executrix of the late Samuel Brown, for improvements in the manufacture of metallic casks and vessels. (A communication.)—July 17.

John Silvester, of West Bromwich, Stafford, whitesmith, for improvements in straightening, flattening, setting, and shaping hardened steel.—July 17.

Ezekiel Edmonds the younger, of Bradford, Wiltshire, cloth manufacturer, for improvements in the manufacture of certain descriptions of woollen fabrics.—July 17.

Henry Bessemer, of Baxter-house, Old St. Pancras road, Middlesex, for certain improvements in figuring and ornamenting surfaces, and in the blocks, plates, rollers, implements, and machinery employed therein.—July 22.

James Bradford, of Torquay, Devonshire, jeweller, for improvements in locks and other fastenings.—July 22.

Thomas Wills, of Bow, Middlesex, engineer, for improvements in steam-engines and in pumps.—July 22.

Joseph Paxton, of Chatsworth, Derby, gentleman, for certain improvements in roofs.—July 22.

Leonard Bower, of Birmingham, Warwick, manufacturer, and Thomas Fortune, of Harborne, Stafford, mechanic, for certain improved machinery for manufacturing screws, bolts, rivets, and nails.—July 23.

William Beetson, of Brick-lane, St. Luke's, Middlesex, brass-founder, for improvements in water-closets, pumps, and cocks.—July 23.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in obtaining, preparing, and applying zinc and other volatile metals, and in the oxides thereof, and in the application of zinc, or ores containing the same, to the preparation or manufacture of certain metals or alloys of metals. (A communication.)—July 23.

George Hazeldine, of Lant-street, Southwark, Surrey, carriage-builder, for improvements in the construction of wagons, carts, and vans.—July 23.

Henry Constantine Jennings, of Great Tower-street, London, practical chemist, for improvements in rendering canvas, and other fabrics and leather, waterproof.—July 23.

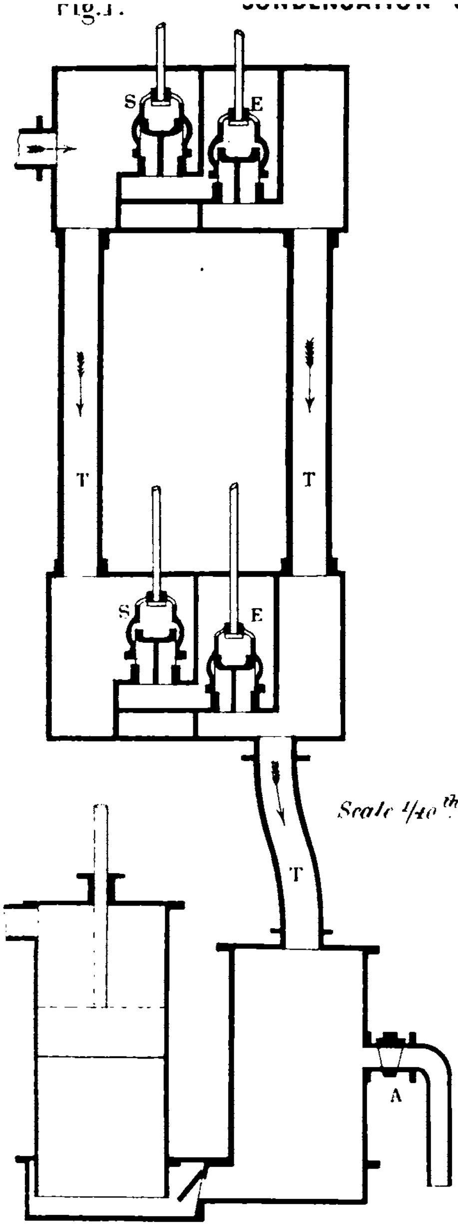
William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in machinery for cutting files. (A communication.)—July 23.

George Dunbar, Esq., of Paris, for improvements in suspending carriages.—July 23.

Langston Scott, of Moorgate-street, London, wine merchant, for improvements in a mode or modes of preparing certain matters or substances to be used as pigments.—July 24.

Charles William Bell, of Manchester, Lancaster, for improvements in apparatus connected with water-closets, drains, and cesspools, and gas and air-traps.—July 25.

Fig.1. CONDENSATION OF STEAM Fig.2.



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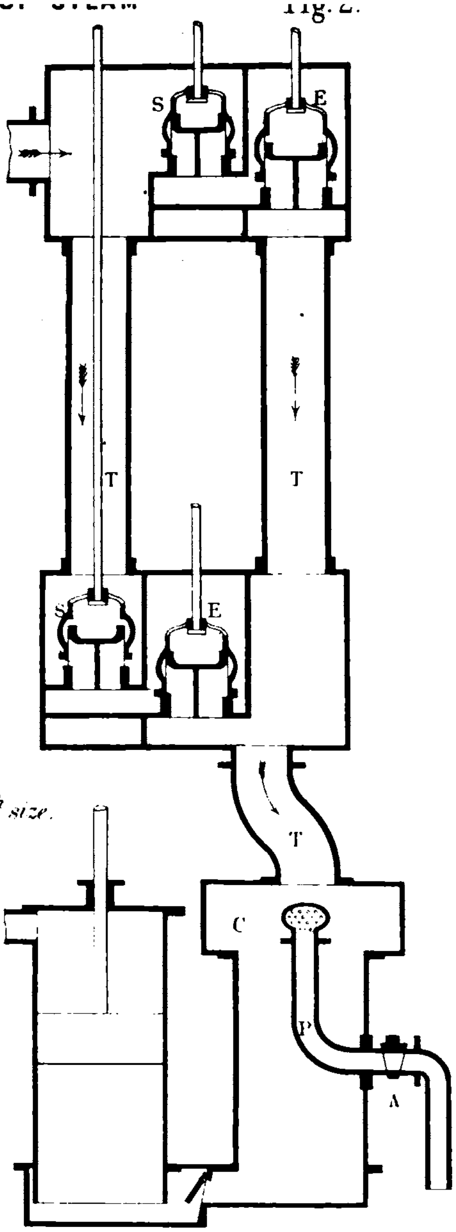

BLOWING ENGINE.

Plate 10

Fig. 4. Plan.

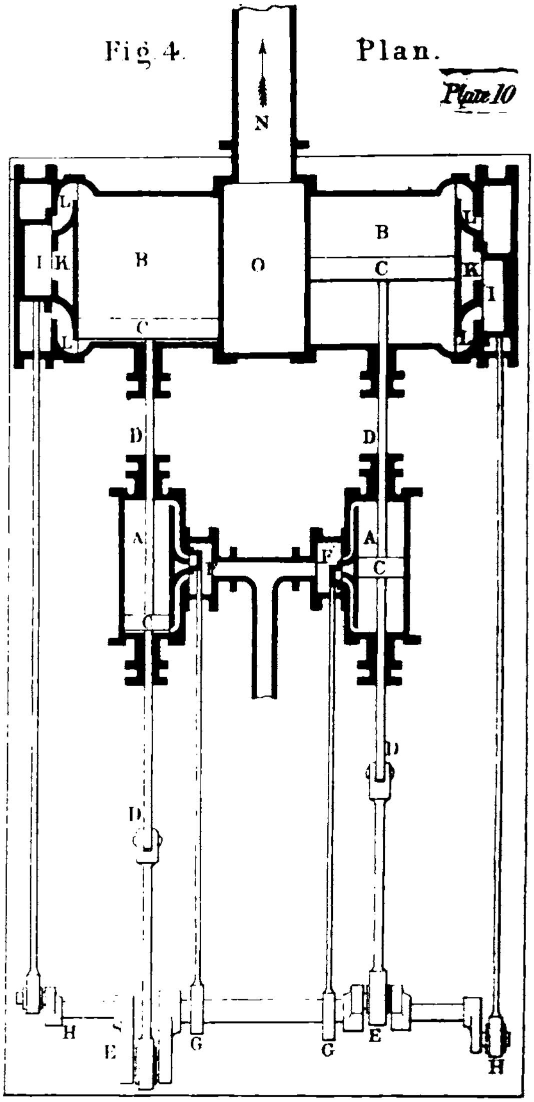

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Fig. 3. Diagram from Mill Engine altered.

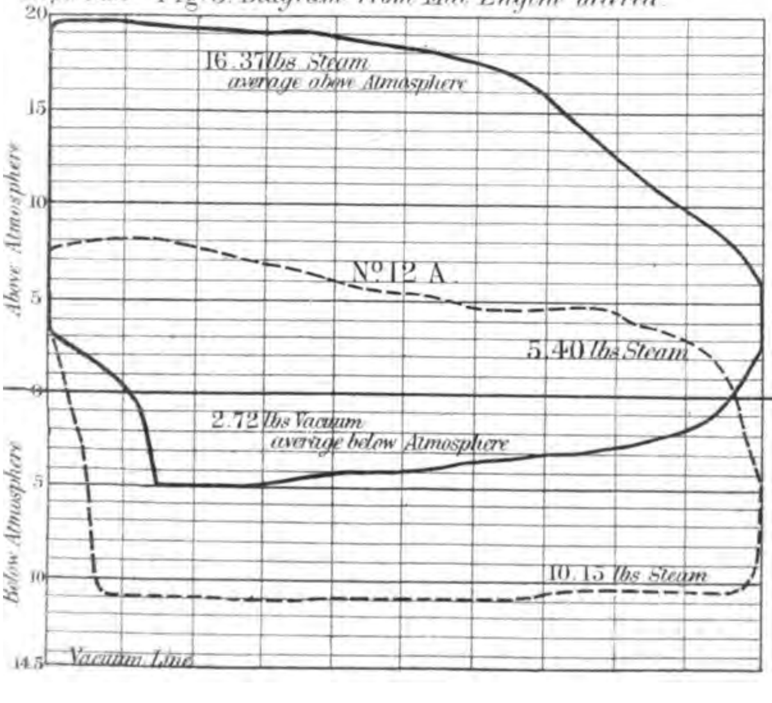
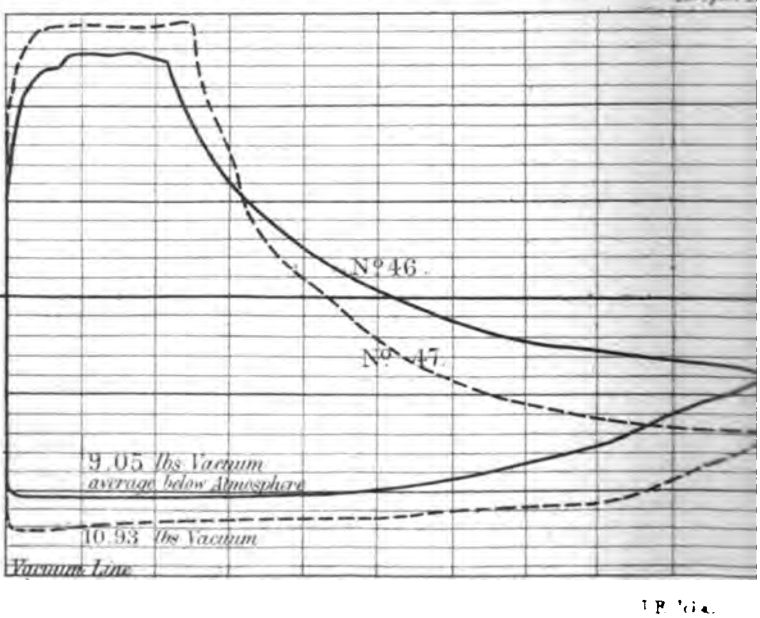


Fig 5. Diagram from pair of Blast Engines.



ON CONDENSING STEAM ENGINES.

(*With Engravings, Plate* X.)

On the Condensation of Steam in the Engines of the South Staffordshire Iron District, and the Improvements to be effected in them. By William Smith, of Dudley.—(Read at the Institution of Mechanical Engineers.)

The object of the present paper with the accompanying series of Indicator Diagrams, which have been taken from the several engines by the author of the paper, is to show the present working condition of forty-eight of the largest class of mill, forge, and blast engines in South Staffordshire, with some remarks as to the practicability of improving them.

The general character of the Indicator Diagrams of the majority of these engines, shows a considerable pressure of steam, continued nearly uniform throughout the whole stroke of the piston, and averaging about 12 lb. per square inch above the atmosphere in the forge and mill engines, and about 7 lb. per square inch in the blast engines; with a very defective vacuum, commencing about the atmospheric line, and reaching only from 7 lb. to 11 lb. per square inch below the atmosphere at the end of the stroke, the average vacuum being about 6¼ lb. per square inch below the atmosphere throughout the stroke. Some of the Indicator Diagrams from blast engines show a considerable expansive action, but not a good vacuum.

Fig. 3, Plate X. shows the Indicator Diagram from a mill engine of 42-inch cylinder and 7 feet stroke, making 17 strokes per minute, which was working very imperfectly in the condensation of the steam, and has been improved to a remarkable extent, by an alteration made for the purpose of improving the vacuum, which has effected a very considerable saving in the consumption of fuel. This engine was working with 12½ lb. pressure of steam at the beginning of the stroke, continued to 17½ lb. pressure at the middle, and reduced to 6 lb. per inch at the end of the stroke, by wire-drawing the steam without any cut-off expansion-valve; the average pressure being 16·37 lb. per square inch throughout the stroke; the average vacuum was only 2·72 lb. per square inch below the atmosphere, beginning a little above the atmospheric line, and reaching only 5 lb. below the atmosphere at the end of the stroke. This performance being so bad it was considered necessary to examine the engine, and the cause was found to be from the valves, thoroughfares, and condenser, being much too small for the proper proportion, the steam and eduction valves being only 7 inches diameter, and the thoroughfares of the same size; these were therefore removed and replaced by others, the steam valves being 10 inches diameter, and the eduction valves and thoroughfares 12 inches diameter, or three times the area of the original ones. The condenser was also nearly doubled in capacity by attaching a large vessel on the top of it, which made it rather larger than the regular proportion; the air-pump was only 24 inches diameter, with half the stroke of the steam piston, or about one-fifth less contents than the regular proportion for the size of the cylinder; this was not altered, but there was an abundant supply of cold water for injection.

The result of the above alteration is shown by the dotted lines 12 a, fig. 3, the steam pressure being 8 lb. at the beginning, and reduced to about the atmosphere at the end of the stroke, the average being 5·40 lb. instead of 16·37 lb. per square inch pressure throughout the stroke; the vacuum commenced at 10½ lb. and ended at 11 lb., the average being 10·15 lb. instead of 2·72 lb. per square inch below the atmosphere throughout the stroke. The improvement in the vacuum amounts therefore to a constant average pressure of 7·43 lb. per square inch throughout the stroke; the total power of the engine as shown by the first diagram, was 19·09 lb. per inch on the piston throughout the stroke, being 190 horse-power, consequently this improvement of the vacuum amounted to 39 per cent. of the total power of the engine or 74 horse-power.

The mode of effecting the above alterations (No. 12 Engine) is shown in figs. 1 and 2, Plate X. Fig. 1 shows the engine before the alteration, the steam valves S, the eduction valves E, and the thoroughfares T being only 7 inches diameter. Fig. 2 shows the engine after the alteration, the steam valves S are increased to 10 inches diameter, and the eduction valves E and thoroughfares T are 12 inches diameter; the new valves being so much larger than the old ones, a different arrangement was required to make room for them, the spindle of the lower steam valve being carried up the side pipe, as shown in fig. 2, and the upper eduction valve placed over the other side pipe, so that three of the valve spindles are worked at the upper steam chest, and one only at the lower. The addition made to the condenser is shown at C, fig. 2, which was a circular vessel constructed of boiler plate, 3 feet 6 inches diameter, and 15 inches high, fixed on the top of the condenser. A further improvement was also made in the condenser, by cleaning out the deposit of lime, and adding an internal injection pipe and rose P; there was no internal injection pipe previously, but simply a hole in the side of the condenser, where the injection-cock A was fixed on, as shown in fig. 1, and consequently the injection water was much less efficient in condensing the steam, being poured into the condenser in a single stream instead of being scattered in a number of small jets from the rose end of the pipe.

The majority of engines in this district are similar in this respect, and the reason that has been given is, that the rose is apt to get the holes choked up by deposit from the water, which is very much impregnated with lime. This is a matter requiring particular attention in this district, and cases have come under the writer's observation, where condensers were filled up by the deposit in the course of two or three years' time, to such an extent, that the capacity was reduced fully one half, as well as the passage through the foot valve; it is a very hard calcareous deposit which adheres firmly to the cast-iron, and requires considerable labour to cut it out, involving a serious stoppage of the engines, and they were consequently worked as long as possible before taking off the condenser cover to cut out the deposit, which increased to 7 inches thickness, and as much as half a ton weight in one engine. Besides the very important saving effected by the greater power obtained from the steam, in consequence of the improvement of 39 per cent. in the vacuum, as described above, the engine has been found to do the work more regularly and satisfactorily since the alteration, than before; it was liable to be pulled up by any extra strain of the rolls, &c., whenever the piston was getting in want of repacking, the leakage of steam injuring the vacuum on account of the very deficient condensing power; but that has not occurred since the alteration was made. The engine drives a merchant mill of 3 pair of rolls, a guide mill of 3 pair, 2 pair of forge rolls, a forge hammer, 2 shears, and a pump for draining the foundations. It was not stopped longer than three days to make the whole of the alterations described above.

Another similar engine of the same size as the preceding, was also examined, in consequence of the imperfection in its condensing, and the valves and thoroughfares were found to be 10 inches diameter, but the valves had not sufficient lift, the eduction pipe to the condenser was 9 inches diameter, and the condenser was 2 feet 4 inches diameter, and 4 feet 6 inches high; the eduction pipe was then removed and replaced with one 12 inches diameter, also a large vessel was fixed on the top of the condenser, which increased its capacity about one-third. The lift of the valves was then increased from 1⅛ inch to 2⅜ inches, and the result of the alteration was an improvement in the vacuum of from 1·50lb. to 7·97lb. per square inch below the atmosphere, or 6·47lb. per square inch increase of average pressure throughout the stroke.

The saving of fuel from these alterations has not been well ascertained, as the engines in both cases are worked from a series of boilers which also supply steam to other engines upon which the load is very unequal, but the saving is admitted to be very considerable, and in the case of No. 17, the proprietors have been enabled to use an inferior description of slack, and also to throw off one boiler, with a fire grate about 7 feet square, and 45 square yards of heated surface, without any diminution in the power employed.

The aggregate power of the 45 mill, forge, and blast engines from which the Indicator Diagrams are taken, is nominally 3240 horse-power, according to Boulton and Watt's proportions of the cylinders, but by the calculation of the Indicator Diagrams, the total is 7819-horse power; the average vacuum obtained in the present working of all the engines is about 6lb. per inch below the atmosphere throughout the stroke, omitting from the average four. which are exceptions to the general run of these engines; and the average vacuum obtained in the six expansive engines, of which Indicator Diagrams are also given, is 10½lb. per inch below the atmosphere throughout the stroke. The loss of power from the imperfect vacuum in the former engines may therefore be taken at the difference between these pressures, or 4¼lb. per square inch pressure throughout the stroke, which amounts to 1930 indicated horse-power upon these engines; or in other words, an additional power of 1930 horse-power, or 25 per cent.

increased power might be obtained from the same expenditure of steam, and consequently of fuel, if the vacuum were improved so as to be as good as the average of the six expansive engines, or 10¼lb. per inch throughout the stroke. This vacuum has been obtained in the two engines, Nos. 12 and 17, which have been altered as before described, although in these engines the alteration was carried out only to a limited extent, and at a comparatively trifling expense; but if it were carried out efficiently by attaching expansive gear in addition to the alterations that have been made, a much better effect would be obtained by using the same volume of steam expansively.

In many cases the expansive action is accomplished by the addition of a separate expansion valve in the steam pipe, which is worked by a cam, so as to cut off the steam at any portion of the stroke that may be desired, this valve opening and shutting twice for each double stroke of the engine; the steam and eduction valves are worked by a common eccentric motion, the top and bottom valves opening and shutting together. But this is an imperfect mode of obtaining expansion, because the steam filling the side pipe and the two steam chests expands after the cut-off valve is shut, and this steam forms a considerable proportion to the contents of the cylinder.

The only efficient mode of applying expansive action, is by lifting each valve by a separate cam, so adjusted as to shut each steam valve at whatever point of the stroke may be desired, whilst the eduction valve is held open till the termination of the stroke; by which means the full effect of the expansive action is obtained. The difference in effect between these two modes of cutting off the steam, is shown by the Diagrams Nos. 46 and 47, Plate X., which are taken from a pair of blast engines working coupled together, and with no difference between them except that in No. 46 the steam is cut off by a separate expansion valve in the steam pipe, and in No. 47 the valves are lifted by separate cams.

But independent of the loss sustained by not working expansively, the loss of power in the engines described being 1930 horse-power, as shown before, the annual loss in money by extra consumption of fuel in these engines, calculating 20 lb. of slack per hour, for one-horse power, at a cost of *3s.* per ton, will amount to 18,610*l.*, or *2l. 7s. 7d.* per horse-power per annum.

The total power of the steam engines employed in the manufacture of iron in the district, may be computed to be fully ten times the nominal power above named; and the total annual loss to the proprietor from the causes described in the present paper, may be therefore taken in round numbers at 180,000*l.* per annum, as the more expansive engines described above may be considered a fair average of the engines in the district.

It has been generally considered hitherto, that the improvement of expansive action of steam was not applicable advantageously to the engines of this district, because of the small cost of the fuel employed; but this will be seen to be an erroneous conclusion from the actual results of the alterations described above, where the improvement was only effected in the vacuum, and the expansive principle was not carried out, which would have effected a still greater saving. The total quantity of fuel consumed at present is so large, that although the price per ton is insignificant, the total amount of saving effected by the per centage on the whole is very important.

In addition to the saving in cost of fuel consumed, a very important saving would also be effected in the tear and wear of the boilers, which is fully in proportion to the extra fuel burnt under them, and the repairing of which is invariably attended with serious inconvenience and expense.

The description of boilers in general use in the district, and the further saving to be effected by improvements in their construction and mode of setting, is also an important practical subject for consideration, and is intended to form the subject of another paper, to be laid before the Institution at a future meeting.

Remarks.—Mr. M'Connell said, he believed the writer was quite within bounds when he estimated the saving in fuel which might be effected in that district alone, at 180,000*l.* per annum; nor was the subject of importance in that light merely, because it was found to prevail as a general rule, that the amount of destruction in machinery and boilers was nearly in proportion to the quantity of fuel consumed. He had remarked at a former meeting on the practical importance of obtaining comparative accounts as complete as possible of the consumption of fuel, and economy of working of the steam-engines in the different districts of the country, and he thought that all information of that kind was of great practical value.

Mr. Bowman inquired whether, in most of the engines mentioned, the proportions of Boulton and Watt were observed in the condenser?

Mr. W. Smith replied, that speaking generally he believed that was the case, but the bad working of the engines was accounted for by the extraordinary pressure of the steam used. The error was, that engines intended and proportioned for 3 lb. steam were worked up to 12 lb. or 16 lb. per inch throughout the stroke, and consequently, they were very imperfect in their condensing; as there was so much larger quantity of steam to be condensed at each stroke, when the cylinder full of high pressure steam expanded down to the same pressure as the low pressure steam.

Mr. Bowman observed, that this would seem to imply that the size of the condenser should be regulated by the pressure of the steam in the cylinder.

Mr. Cowper said, the pressure of the steam was certainly a necessary element to be taken into consideration, as well as the size of the cylinder, in determining the size of the condenser. There was not only a greater quantity of steam to condense when a higher pressure was employed, but also a greater quantity of air to pump out at each stroke of the air pump. He mentioned a case which came within his own observation in that district, where 18 lb. steam was employed; there was no barometer guage, but the parties were satisfied that they had a good vacuum; however the fact was, that the injection water was forced into the condenser by means of a cistern at the top of the engine house, 22 feet in height.

Mr. Slate remarked, that he fully concurred in the results obtained by Mr. Smith, but feared they were so startling that there would be a disinclination to give them credence in the district. It was highly important then that the truth of the deductions should be practically admitted

Mr. T. Thorneycroft, as an iron-master of the district referred to, felt extremely obliged to the author of the paper pointing out the means whereby any saving could be effected, more especially at a time when, owing to the state of the trade, economy in the manufacture was so essential.

Mr. W. Smyth said, it had often occurred to him, that a steam engine was like no other machine. A time-piece, if out of order, was sent back to the maker to be repaired; and in the case of machines of other descriptions, if they did not do their work well they were immediately stopped, because they wasted and injured the material upon which they were employed. But when the old steam-engine, after twenty or thirty years' of hard labour, showed some symptoms of disorder, it could not be stopped, so with an extra application of the coal shovel, and some hammering at the cotters, &c., it was set to work again, and with its powerful steam arm it wound round all the complicated machinery. This, however, was done at an enormous expense to the proprietor of the engine, and it would be much better if he were to renovate its constitution. He trusted that the exertions of the members of the Institution would have some influence in showing to persons of the description referred to, the necessity of carrying out these things on more efficient principles than they had hitherto been conducted.

Mr. Bowman thought it a matter of great importance that the injection water should spread itself out amongst the whole quantity of steam immediately on its passage into the condenser, and the alteration made by Mr. Smith in the mode of injection was very advantageous.

Mr. Cowper observed, that they ought all to add their testimony to the value of the Indicator Figures produced by Mr. Smith, because they showed the character of the engines much better than any judgment which could be formed with reference to them, inasmuch as it was the character of each engine written by itself, and could not be erroneous. He had not the slightest doubt, that a loss of 180,000*l.* at least, as stated by Mr. Smith, was sustained in that district, because the mode of condensing ordinarily adopted was exceedingly defective. It had occurred to him many years ago, that a valve might be put at the side of the condenser, and connected with an injection pump, so that a gush of cold water might be injected at every stroke, at the very moment of the entrance of the steam into the condenser, and shut off again immediately, by which means the greatest possible use might be made of the injection water, and the condensation of the steam effected with a smaller quantity of injection water. He then explained the drawing of an improved injection valve which he had constructed, and found to work very successfully; the object was to maintain the full pressure of the water at the point of entrance into the condenser, and to obtain a more efficient distribution of the jet of water without danger of its getting choked. In fig. 5, A is the condenser, B the eduction pipe, C the air pump, D the cold water cistern in which they are immersed; E is the injection valve, a conical valve rising a little above the bottom of the condenser, with a perforated cap below in the cold water cistern: this valve is lifted by the screwed rod F, and the admission of the injection water can be regulated with the greatest accuracy by the screw.

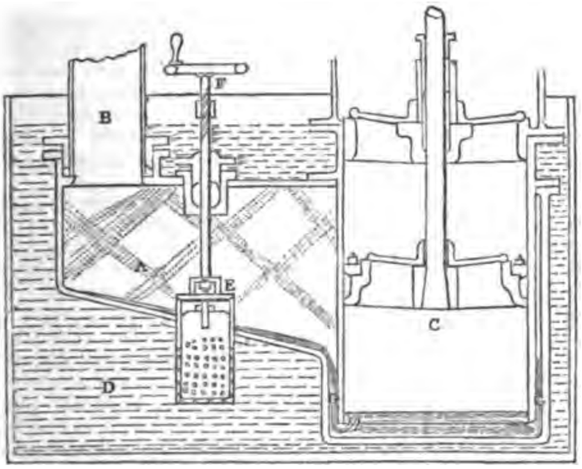


Fig. 5.

The water enters the condenser in a fine sheet all round the valve, which strikes the sides of the condenser and fills the whole space with a fine spray; he had ascertained this by trying the valve in a box similar to the condenser, but partially open, with a column of water of the same pressure as the injection, and he found the distribution of the water was so perfect as to fill the box with a complete spray or fog. There was also a different construction in the air-pump which he considered advantageous; the bottom dropped into a well G G, in the bottom of the condenser, and the water rose up the space G G, when the air-pump bucket dipped into it, forming a water-valve instead of the ordinary foot-valve, and giving pressure enough to ensure the bucket-valve opening if there was any obstruction. An indicator figure, taken from the engine when in full work, at 24 revolutions per minute, driving shafting and two fans, indicated $72\frac{3}{4}$-horse power. By an indicator figure of the same engine when part of the work was thrown off, it amounted to $38\frac{1}{2}$-horse power; and by another indicator figure for the engine and four lines of shafting alone, without any work, amounted to 14 horse-power, at the same speed of 24 revolutions per minute. The engine is high-pressure, expansive and condensing, and is one of a pair working coupled together; there was originally in their place, a pair of high-pressure engines, non-expansive and non-condensing, and the comparative economy of power effected by the present engines is so great, that although the same boilers only are used, there is $2\frac{1}{4}$ to $2\frac{1}{2}$ times the power obtained. The indicator figures exhibited by Mr. Cowper to the meeting, were drawn to the scale of 20 inches length of stroke, and $\frac{1}{2}$-inch for each lb. of pressure; and he begged to suggest that scale as a convenient one to be adhered to, for indicator figures intended to be exhibited to the Institution.

Mr. **Slate** thought the plan of injection proposed by Mr. Cowper, was a very eligible one. With reference to the alternate injection of the water, he had experienced the difficulty in marine engines, of too much water being admitted by the injection cock, whenever the engines were working slowly, causing the injection water to choke up the condenser, and even get up into the cylinder, and he had adopted a slide valve in the injection pipe, admitting only water enough at each stroke of the engine for the condensation of the steam; the jet of water was thrown against a perforated distributing plate.

Mr. **M'Connell** remarked that, there would be a tendency in the rose of the injection pipe, as adopted by Mr. Smith, to become choked up.

Mr. **Cowper** observed that in the plan he had described, that difficulty was quite obviated, as in the case of the circular valve becoming choked, they had only to lift it up an inch or two by the screw handle, and then screw it down again, and the rush of water would effectually wash out any obstruction.

Mr. **M'Connell** considered that a great advantage, as it would prevent any stoppage of the engine. He thought the members of the Institution were much indebted to Mr. Smith for his researches, but their obligations were small compared with those of the iron manufacturers of the district, with whom he had been more immediately brought in contact, as the saving proved to have been effected by the improvement of the engines, formed so serious a proportion to the whole expense of working them. It was important that this subject should occupy the attention of the iron masters, because their material must bear a proportion in its price to the management bestowed in its manufacture. He hoped Mr. Smith would not lose sight of the subject, but keep it prominently before, not only the iron manufacturers of South Staffordshire, but the owners of steam-engines throughout the country; and he thought this Institution was an excellent vehicle for the purpose, because it was only by such an Institution that information could be collected in a practical form, and the results be duly investigated and considered. In conclusion, he proposed a vote of thanks to Mr. Smith, which was passed.

BLOWING ENGINES.

(*With Engravings, Plate* X.)

On a Blowing Engine working at High Velocities. By **Archibald Slate**, of Dudley.—(Paper read at the Institution of Mechanical Engineers).

Mr. **Slate** directed attention to the various changes through which this description of engine has passed, the better to elucidate the difficulties to be overcome, and the advantages to be derived from the further change now proposed.

The first records he has been able to collect show the blowing cylinders to be single-acting, or having the power of propelling the blast when the piston was moving in one direction only; three or more of these blowing cylinders appear to have been attached to one crank-shaft, worked by a water wheel, and thus a tolerably steady pressure of air has been obtained. When the gradual improvements of the steam-engine and the demand for increased means of manufacture caused it almost entirely to supersede all other power, the blowing apparatus appears to have been accommodated as much as possible to the steam-engine, so as to afford the character of engine for the time being, the fullest development of its power.

In pursuance of this object, the single-acting atmospheric engine of Newcomen was attached to a blowing cylinder, which propelled the air from the upper side of the piston only, and in addition to the water regulator, which appears to have been known at an earlier date, there was attached a cylinder, now known as the regulating-tub, which was equal to or larger in diameter than the blowing cylinder. In this was fitted a piston with a rod moving in a guide fixed on the open top of the regulating tub, the bottom of the latter being close, and having an open connection to the main from the blowing cylinder. The piston in the tub was loaded to the pressure of blast required, and in the intervals between the discharges of the blowing cylinder, the descent of the piston in the tub kept up the discharge of air into the water regulator, which intervened between it and the furnace; thus in effect, as far as possible, making the engine double-acting. To prevent the piston being blown out of the regulating tub, a large safety-valve was attached to the top of the rod by a strap, long enough to allow the desired play of the piston, and short enough to lift the safety-valve, or snorter, as it is usually termed, if the piston at any time exceeded its limits; and the number of strokes of the engine were also regulated by the tub piston, as to it the cataracts were attached.

When the double-acting engines of Watt were introduced, the regulating tub was still retained, though not nearly so essential a part of the machine as in the former instance.

The next change that took place was the general abandonment of the water regulator (though some of these are still at work, or have been within a few years); the reason for this change was the discovery that the air in summer, already surcharged with moisture, took up an additional quantity from passing over the surface of the water in the regulator, and that this was prejudicial to the working of the furnaces.

When the large area of the water regulator was shut off, it was then found that the tub was by no means such a perfect regulator as it was supposed to be, as the momentum of the engine passed too sudden into the heavy piston of the tub, and throwing it up much beyond the height due to the pressure of the air, caused an irregularity that was even more aggravated by its descent; to counteract this, a spring beam was placed on the top of the tub so as gradually to check the momentum of the piston, and this had some effect, but not at all a satisfactory one.

The next alteration which appears to have suggested itself, was the application of large air chambers, from twelve times to thirty times the area of the blowing cylinder, in which the elasticity of the compressed air acted as the regulator of the discharge, the tub with its piston being in some cases retained to work the cataracts, and as a tell-tale against the engine men, in case of their allowing the steam to slacken and the piston to descend.

We now enter upon the last change which took place some fifteen years ago, namely, the coupling of two double-acting engines, and double-acting blowing cylinders upon the same crank-shaft at right angles, so as to keep up a regular discharge. This effect was in some measure obtained, but an air chamber, or, what is equivalent to it, very large mains, were still required to obtain what was considered a satisfactory result.

At this point the realised improvements of the blowing engine stop short, leaving it still a large cumbrous and expensive machine, and not capable of moving through its valves the highly elastic medium air, at a greater rate than the absolutely non-elastic fluid water, is moved through an ordinary pump. Under these circumstances, it must be obvious that after all the engineering talent that has been spent on this description of engine, there is still (if the expression may be applied) a wide range of discovery open.

The immediate cause of the writer's attention being attracted to the improvement of the blowing engine, was the difficulty experienced in regulating one of the old construction of blowing engines in the latter part of 1848, and having at the same time occasion to employ some small 9-inch cylinders driven by the air of the large blowing engine. These small cylinders when driving the shafting only, sometimes attained a velocity of upwards of 200 revolutions per minute, suggesting the idea of the possibility of reversing their motion and taking in the air in place of blowing it out through them; there was however a difficulty in the slide valve which did not open and shut fast enough. After some consideration it was agreed that another cylinder should be prepared, and the centre port made much larger, and the slide overtravelled nearly half its stroke in excess, which had the desired effect; a cylinder of 9 inches diameter, and 1 foot stroke, having been driven 320 revolutions or 640 feet per minute, discharging the air at a pressure of 3½ lb. per square inch, through a tuyere of 1⅛ inch diameter, or $\frac{1}{64}$th of the area of the blowing piston. This performance, as is well known, is more than double that of any ordinary engine, the total area of the tuyeres with a 90 inch blowing cylinder, being at a pressure of 3½ lb., about 52 circular inches, or $\frac{1}{154}$th of the area blowing piston.

We are all acquainted with the tremour which is felt even in the best form of the large sized engines; but in the experiments at a high velocity with the small sized cylinders, not the slightest jar was felt or noise heard, it is therefore proposed to increase the speed of the piston in actual practice, from 640 to 750 feet per minute, the length of stroke being 2 feet in place of 1 foot; this is somewhat under the speed of a locomotive piston at 40 miles per hour, which is about 800 feet per minute, so that it is conceived no difficulty can present itself to this. The proposed speed of 750 feet per minute, is three times the usual speed of the present blowing engines, 250 feet per minute.

The construction of the proposed engine is shown in the accompanying engraving, fig. 4, Plate X., showing the plan of a pair of horizontal steam cylinders and blowing cylinders; A A are the steam cylinders, 10 inches diameter and 2 feet stroke; B B, the blowing cylinders, 30 inches diameter and 2 feet stroke, with their pistons C, fixed on the same piston rods D, which are connected to two cranks E, fixed at right angles to each other on the same shaft. The slide valves F, of the steam cylinders are worked by the eccentrics G, on the cranked shaft, and the cranks H, at the outer ends of the same shaft, work the slide valves I, of the blowing cylinders. The centre port K, passes downwards to an external opening for the admission of the air, and the discharge ports L L, deliver into the passages M, on the top of the cylinder, which communicate with the air main N, by the chest O, formed between the cylinders. The piston of the blowing cylinder is intended to be made without any packing, being a light hollow cast-iron piston turned to an easy fit; and the slide valve of the blowing cylinder to have a packing plate at the back, working against the cover of the valve box, with a ring of india-rubber inserted between this plate and the back of the valve, to give a little elasticity.

It appears that 30 inches diameter is somewhere about the most convenient size for a stroke of 2 feet, and as it is considered an advantage to have the stroke as short as possible, to increase the regularity of the blast, the comparative cost of the different engines which follows has been taken upon this basis two 10-inch steam cylinders and two 30-inch blowing cylinders, costing together (exclusive of the boilers,) about 400*l*, being reckoned equal to blow one of our largest furnaces, making 160 tons of iron per week, and having a surplus equal to blowing a cupola or refinery, as is generally allowed, as such an engine would give at 640 feet per minute the same speed of piston as in the experiments, very nearly 30 circular inches of tuyere, at a pressure of 3½ lb. to the square inch; the circular inch is used in speaking of the area of tuyere, as the blast that any furnace is taking is usually reckoned by simply squaring the diameter of the tuyere, but the pressure is taken on the square inch.

The experiments on which these calculations were founded, having been made upwards of 12 months ago, were repeated last week, and the results were found to be as nearly as they could be measured the same, the blowing cylinder had in the interval been driving the lathes in the pattern shop, and the slide was found perfect. An indicator was applied with a view to test the amount of friction of the air in entering the cylinder at the high velocity, and a simple method was adopted of ascertaining this. A tuyere was made as large as the inlet port, and the engine was driven to nearly or quite 700 feet per minute, when the guage showed a pressure of ¼ of a lb. per square inch; and as the friction would be the same through the same sized openings at other pressures, it follows that the loss by friction on a pressure of blast of 3½lb. per inch, would be $\frac{1}{15}$th or 6⅔ per cent loss; as the port in this case was $\frac{1}{11}$th of the area, and the port proposed is ⅛th, it is assumed that the loss would not exceed 5 per cent. from this cause, or indeed from any other cause, as the friction from propelling the air through a given sized tuyere, at a given pressure, must be the same in both cases.

Following up the comparison of first cost, we find (that exclusive of boilers, which are assumed the same in both cases, but taking into account the cost of the engine house,) there would be a saving by the proposed plan of between 65 and 70 per cent.; the cost of a pair of the best engines in Staffordshire, blowing three furnaces, being 3650*l*., while on the proposed plan they would cost 1100*l*. if high pressure only, or if high pressure and condensing 1350*l*., including in each case the engine-house but not the boilers.

Many will prefer high pressure only, on account of its simplicity, but as it appears evident that a given quantity of steam can be condensed in the same time, in the same condenser, whether admitted in a few large jets or in a great number of small jets, there is no reason whatever why a condensing apparatus may not be attached to the short-stroke engine at high velocities; the only condition being that it must be equivalent to the power of the engine without relation to the size of the cylinder. The air-pump in this case must be double acting with slide valves, or it may be rotary and placed round the crank-shaft, and there appears to be no advantage in a fly-wheel for such an arrangement of blowing engines.

The speed of the engine should be regulated by a hydrostatic governor, communicating with the blast main, and attached to the throttle valve, exactly similar to those used in gas works for regulating the engine driving the exhausters; this would regulate the engine with greater delicacy, and maintain a more uniform blast than can be done with the present engines; and the rapid succession of the strokes of the two small blowing cylinders acting alternately, would render the present large reservoir quite unnecessary.

Supposing the advantages claimed for this description of engine to be realised, which the writer has no reason to doubt, it may be applied to assist the present blowing engines where they are overpowered, which is in many instances the case, as there is no ready means of increasing their power as the works develope themselves, and greater calls are made on the engine; but in the case of the proposed engines, if at any time an increase were desired another blowing cylinder might be added to the shaft, at a comparatively small cost.

Referring again to what first drew the attention of the writer to this subject, the employment of small cylinders worked by the pressure of air, where it was inconvenient or impracticable to employ shafting; it has been found that a 12-inch air cylinder with 3 lb. pressure attached to a large foundry crane, under which fifteen 30-inch pipes are cast vertically every ten hours, does the work of double the number of men that could by any possibility work at the crane.

This suggests the possibility of a very considerable advantage to railway companies, by the use of the proposed engines, as the blowing cylinders for compressing the air might be attached to the end of the piston-rod of any of the small-sized engines now laid up at several stations, and the air conveyed to the various cranes, to which cylinders might be attached for about 25*l.* per crane, without disturbing the present arrangement for the use of manual power in cases of emergency. The saving of manual labour by such an arrangement will be best estimated by the managers of goods departments, some of whom are amongst the members, and with reference to the mechanical application of the power, the writer hopes to have the pleasure of presenting the Institution with another paper at some future meeting.

At the conclusion of the reading of the paper, several questions were put to Mr. Slate, and which he answered. He stated that he had used fans made according to Mr. Buckle's principle, and could speak to their excellence and superiority; they were the least expense in construction, being made with light wood arms, and he had obtained from 4½ to 5 oz. per square inch pressure with them. He had tried both the cylinder-blast and the fan-blast for melting iron, and indeed had them both now in use; but he was of opinion the cylinder-blast was decidedly the best for the purpose, as the fan-blast caused the lining of the cupola to burn away quicker, and also consumed a larger proportion of fuel. He had found they could not blow so continuously with the fan-blast, and required to stop more frequently for repairs of the lining than with the cylinder-blast. The pressure of the fan-blast was not sufficient to carry it through the burden, so that the passage of the air was more at the sides of the cupola, which caused the lining to be cut away, and hence he considered the cylinder-blast was the best for melting iron; and though it might not be so cheap at first cost, there was no doubt of its ultimate economy. In the thousands of tons which he had melted, he had been unable to detect any difference between the quality of iron made under the influence of the fan and that made by the cylinder-blast. The pressure with the cylinder-blast was about 3¼ lb. per inch at the cupola, and they had six 1-inch or 1½-inch tuyeres. In the case of the fan, they had two tuyeres about 6 inches in diameter. They used best Durham hard coke, because light coke was useless with the cylinder-blast, which would blow it away.

Mr. Davies said, he made an exhauster that had been used extensively for blowing copper-melting furnaces, but he believed the fan was preferred, though it gave less pressure of blast.

Mr. Robinson thought the fan-blast was best for a cupola, and he could not see the reason why the cylinder-blast should not injure the sides of the cupola more than the fan-blast, because it had greater pressure, and must have more power to force its way through to the opposite side.

Mr. Cowper thought there would not be any greater destruction of the lining with the fan-blast, unless there were some other cause; the circumstance of blowing with six tuyeres in the one case, and only two in the other, might cause a difference. At the London Works the cupola was blown with a fan-blast, and had two 10-inch tuyeres at 5 oz. pressure, but they did not find the sides cut away; on the contrary, with some trifling repairs each morning before starting work, the lining of the cupola lasted for many weeks.

Mr. W. Smith remarked, that he did not know any instance of the fan being applied to blast furnaces in that district, and it was for those more particularly that Mr. Slate's engine was proposed; the question raised by the paper, was whether in the case of blast furnaces it was better to employ a small cylinder at a high velocity, or a large cylinder at a slow speed. This small blowing engine was proposed to supersede the ponderous machines which were employed for the purpose at the blast furnaces; he considered it was an important suggestion, and he saw no reason why it should not accomplish the object intended.

Mr. Cowper was of opinion that the proposed quick motion would give a more regular blast, which was a matter of great importance as affecting the make of iron; but it was a question whether the great speed at which it was proposed to be worked would not injuriously affect the durability of the working parts of the engine.

Mr. M'Connell did not think there was reason to fear any serious objection from that cause, when it was borne in mind that the piston of a locomotive engine frequently worked at the velocity of 800 feet per minute, and the proposed engine would be stationary instead of locomotive.

THE TUBULAR BRIDGES.

The Britannia and Conway Tubular Bridges; with General Inquiries on Beams, and on the Properties of Materials used in Construction. By Edwin Clark, Resident Engineer. Published with the sanction and under the supervision of Robert Stephenson. London: Weale. 1850.

The Tubular Bridges may now be supposed familiar to all; and in taking up a book on the subject, however important, we have some fear lest what we say, as being supposed to be on an old and known subject, should not be listened to. The event is not near enough to have the prestige of novelty: it is not yet far enough for curiosity again to rise as to the actors by whom brought about, and the circumstances attending it. Our reading of Mr. Edwin Clark's book, however, has heightened our feelings; and though in the pages of this *Journal* we have over and over again written of the Britannia Bridge, we are not without hopes that our readers will go with us in reviewing, on this the first complete opportunity, the history of one of the greatest works of modern times, of a great monument of our days, which, notwithstanding the sneers of those who can properly appreciate neither antiquity nor the present, are more fruitful in great moral events, and in vast physical exertions than the world has yet seen. Many of us stand but as flies upon the axles; but as the wheel of Time's car runs swiftly on its way, the wonders of bygone ages are quickly surpassed, and events, each in itself the worthy subject of a history, are crowded before us. When Alexander wept that he had no more worlds to conquer, when Napoleon, greater still, thirsted for victory in Russia, or even when he was tottering to his fall, the world was not so much moved as now; for though the fate of single nations might waver under the beam, the lot of mankind and the welfare of beings yet to be born was hardly at stake. The revolution which has shaken Europe, the sudden chance which has unlocked the golden stores of California and opened a new world in the Pacific, the spreading influence of the older English in China and Hindostan, and the southward march of the two great English races to grasp the lordship of America, are events which would have dazzled the older historians, and awakened the inspiration of a Thucydides, Livy, Gibbon, or Niebuhr; but these events have not come alone. Kings and nations, we know of old, can rise and fall; but time and space, eternal in their laws, are now made sensible to us under very different conditions. Every day we are made more and more aware of the mighty influence of those applications of steam and electricity, by which the ends of the earth are being brought together, and the most distant lands drawn within our reach. In such mighty operations it is that the man of science is made sensible how much, by well-directed exertion, he may influence the destiny of mankind; and even the humble mechanic is called on to take part in these great actions. This is one—not the least important—of the new aspects under which the world appears. Plato might strive to influence statesmen; Aristotle gain the ear of Alexander; Seneca train up a Cæsar and find him a Nero; Bacon vindicate the claim of philosophers to political influence; but such men could never hope successfully to overcome the stubbornness of their instruments, the chances of education, the vicissitudes of party intrigues, or the disasters of barbarian warfare. It is by giving less predominance to speculative science, and a more practical turn to the labours of students, old and young, that a change has been produced; and the modern historian must attribute as great an influence to a Watt, Trevithick, or Stephenson, as the older historians to Socrates, Aristotle, and Bacon. It is not that morals have lost by this change: it is that they have gained by the application of intellect to practical results, instead of the elaboration of a Republic, a Utopia, or an Oceania; and the contrast of the two systems does not rest on a bright image of the present, and a dim remembrance of the past, for we have them face to face by summoning a Kant, Fichte, and Hegel.

If, however, the change is now most apparent, it has not been suddenly brought about, for the foundation is what Bacon laid and Newton worked upon; and the superstructure shows most now, for the foundations are deep. In proportion as this practical system is carried forward, so must the share of the engineer be greater, and the influence of the practical man be increased; and the mechanic will hereafter seek that participation in great deeds in the workshop, for which his fathers shed their blood on the battle-field. In the presence of the moral results that are obtained, the ambition of the engineer will take a nobler direction; and works will be carried out from motives of humanity, the magnificence of which would never attract capital, nor allow of a profit.

The wants of the present day require vast appliances, and the consideration of the instruments which are at our disposal is not among the least pleasing meditations, while casting a hopeful glance at the future. Viewed under the inspiration of all these considerations, the Britannia Bridge seems invested with an influence, the possible results of which can hardly be appreciated. It is not only a great work in itself, but it is an extension of mechanical power such as enables us to work out still grander designs. Everything which is a means to a great end calls for our observation; but those which are the most powerful in their results, whether a telegraph wire or the beam-bridge, justly claim our most serious attention.

The engineer, in contemplating the structures which have given rise to these remarks, neither irrelevant, we hope, nor unworthy of them, will chiefly have regard to two conditions—first, as to the means of completely imitating them, and next, as to the possibility of the application of the same construction on a larger scale. As a record of the Britannia or Conway Bridge, we should care little for any work; but it is in their results, in their influence, that our interest lies. Mr. Edwin Clark, the author, has well understood the conditions required, and he has therefore laid down a text-book, which will not merely be read and referred to, but which will be worked out by the engineer engaged in some like undertaking, perhaps among the steppes of Russia, the jungles of Hindostan, or the prairies of the far west. To enable this to be done effectually, it was needful not only to describe the works, and the way in which they were built up, but to investigate the principles in conforming to which their stability depends. In the case of an arch or suspension bridge, or a lighthouse, this has been already done; but the hollow beam being new, it will be seen how great is the task imposed upon the author; and hence the work, being carefully and ably performed, as here, how valuable in its teachings.

Such then is the book before us, and familiar as its subject may at first sight appear, it is most difficult for us, within our limits, properly to bring it under the notice of our readers, for we should be obliged to enter into many details at the same length as the author, or to reproduce his statements. We are therefore obliged to adopt a less systematic course, and taking it as our text, offer such observations as occur, leaving the analysis of the book to our readers, who will not wait for our bidding to buy it, and who are as it were constrained to read what is the standard work of engineering literature in the present day.

First, we must allude to the feeling of gratification which all members of the profession must entertain towards Robert Stephenson, for promoting the publication of this work. It is a graceful recognition of the duty incumbent on all to contribute to the common stock of knowledge, from which each gleans, and none more than those whose own achievements are greatest; and we feel a personal satisfaction in having constantly urged on the profession the discharge of this duty, because we know that we are answered by the sympathy of those whom we address. We may be forgiven for this personal allusion, because in a profession so newly risen to a great height, neither are the duties of its members well understood, nor the value of a technical periodical properly appreciated. We call the attention of our readers to ourselves, because it is as a means of serving their interests. The more readiness shown in giving information to the public, the greater the aggregate result and the benefit to each; for the influence of the press is not confined to general suggestions, being more especially owing to the diffusion of information to an extent which is little known, and can therefore hardly be conceived. In Mr. Clark's work, at p. 651, will be found a reference to our pages, and others are made by him and Mr. Stephenson to our contemporaries; while within the last few months alone, our pages have been acknowledged as a source of information to members of the profession in Rio Janeiro, in Canada, and in Hindostan. Who cares about giving information to others in India or America, yet it was by gleaning information as to a covered viaduct in America (p. 23), as to an accident in a dockyard at home (p. 30), that Robert Stephenson obtained the corollary evidence on which to justify his vast design. We do not feel disappointed with the success of our exertions—far from it, they are beyond what we could ever have expected; but we speak because we wish to stimulate the great body of engineers to the communication of information upon which too many are neglectful, either as thinking too much of their works, and selfishly keeping their knowledge to themselves, or thinking too little of what they see, and passing over what they think trifles.

Under these circumstances, Mr. Clark's book is invested with the character of a record by its maker, of a great undertaking rather than the narration of an historian. Robert Stephenson has not only supervised the whole work, but he has written a section of it; it contains his letters and reports. But, above all, Mr. Clark was in this whole business his bosom friend and helpmate, knowing of all that was done; partner of every doubt, of every fear and every hope; present at the rise of each new suggestion, and taking part in carrying it to fruition. The book justifies, therefore, the character we have given it, of being one of the great standard works, and we hope many others are to come. In many professions the reward of excellence is so narrow that it is beyond the power of the members to incur any large pecuniary contribution; but the earnings of our great engineers have been so princely as to leave no excuse of this kind, and little time ought to pass before the gigantic undertakings of the day are as well commemorated as the Britannia Bridge, of which we are now speaking, the Menai Bridge by Mr. Provis, the Plymouth Breakwater by Sir John Rennie, and the Skerryvore Lighthouse by Mr. Alan Stevenson. One very memorable circumstance connected with the Britannia Bridge is, the union in its production of the resources of theoretical research and of practical acquirements, and the harmony and zeal with which, with a well-known exception, so many men of various acquirements co-operated in the achievement of this design. Whether it was from fellow-feeling for the engineer, burdened with a task almost impossible, or whether with the earnest desire of ensuring success for a grand conception, certain it is few men have had so many or so able helpmates. The report of the Admiralty engineers, Sir John Rennie and Mr. Rendel, made abortive a very admirable design; and it appears very questionable, whether in the conditions they imposed, they did not seek to make the passage of the railway impossible, and to favour the Porth Dynllaen plan. The tribunal of the Parliamentary Committee was not the most encouraging for the announcement of the new plan; and incredulity was as strongly expressed at the suggestion of a beam 450 feet long, as when the father before a like audience spoke of locomotives running thirty miles an hour. If Robert Stephenson felt seriously the responsibility thrust upon him, he soon received the assurance of co-operation and support. Not only did he have the assistance of Mr. Fairbairn, Professor Eaton Hodgkinson, and Mr. Edwin Clark, but he found a liberal counsellor in the Astronomer Royal (pp. 483, 514), and practical supporters in Mr. Brunel, Mr. Tierney Clark, Mr. John Laird, and Mr. Miller. When it is remembered the feud was still raging as to the broad gauge and the narrow gauge, the atmospheric railway and the locomotive, in which the two great engineers were pitted against each other, and that throughout they have been rivals for fame, it is not the less remarkable, and we are sure not the least pleasing, to find Robert Stephenson and Brunel working freely and earnestly together, and it is an event equally honourable to both. Throughout we find frequent references to communications from Brunel (pp. 101, 437, 461, 488, 510, 643, 680), and a most interesting description of his original application of the principle to a circular beam, 309 feet long, for a bridge over the Wye (p. 102). All the experience he had acquired in getting up the Hungerford Bridge and the Clifton Bridge was readily communicated, as well as that of Mr. Tierney Clark, as to the Pesth and other great suspension bridges.

Another memorable circumstance was the costly series of experiments, and the lengthened scientific investigation forming part of the preparations. Distinct experiments were carried on by Mr. Fairbairn, Mr. Eaton Hodgkinson, and Mr. Edwin Clark, and those of Sir Mark Brunel and his son were freely communicated. These experiments were followed by a careful and laborious mathematical investigation, conducted by Mr. Eaton Hodgkinson, checked by Mr. Edwin Clark, and laid for revisal before the Astronomer Royal, who, in one instance (p. 513), pointed out an erroneous deduction. The experiments began with small tubes and other slight models, and extended to a costly model made one-sixth of the size of the Britannia tube, or no less than seventy-five feet long (p. 184). Of course, the material being only in cubic proportion to that of the great tube, was very small (1 to 216), but the model was so large as to give a near approximation to the condition of the gigantic structure. The experiments of Brunel on a beam of 66 feet long (p. 437) are likewise on a large scale; and what may be called the auxiliary experiments are likewise unapproachable under ordinary conditions. Such are those of Mr. Fairbairn on an iron steam-ship 200 feet long, with 1200 tons of machinery in the middle; and such are those on the tubes themselves while on the platforms. The bridges were likewise the subject of experiment, and the opportunity was thus given of observing a beam 1511 feet long, and weighing 4306 tons. This is an apparatus which Archimedes might have sighed for, and which modern science will know how to turn to account.

The cost of the experiments to the Railway Company was 6530*l.* (p. 811), besides the time of Mr. Stephenson and Mr. Clark, and without reckoning any contribution from extraneous sources. We are therefore justified in considering that a sum of 10,000*l.* was devoted to the experiments on which the tubular bridge was founded, and the book before us written. The experiments consisted of two great series, those at Millwall and those at Manchester. In the Millwall experiments the original cost of the large model was 320*l.*, and the repairs to it in the several experiments 600*l.* 13*s.* 4*d.*, making a total of 920*l.* 13*s.* 4*d.* The Manchester experiments were continued from January to December, 1846, and cost nearly 4000*l.* Some of the tubes tried in experimenting were afterwards used up for chimneys and otherwise on the works at the Britannia.

We shall now turn to a personal question, which is rather of a painful nature; and that is the question between Mr. Stephenson and Mr. William Fairbairn, and with regard to which the profession have looked forward to this book with some anxiety. Hitherto it was difficult to arrive at any correct judgment, though it was easy to see temper had more to do with the matter than anything else. We think we can make out our way more easily now; and we trust in the end these dissensions may be healed, and that we shall no longer on a grave and important subject have to regret bickerings which do injury to the cause of science as much as to the party in the wrong.

From this book there is no opening for doubt that Mr. Stephenson it was who first conceived the idea of throwing a hollow beam or covered bridge over the Menai; and therefore any claim narrows itself to after co-operation as to the development of the idea. Mr. Fairbairn was early called upon to assist, upon the very good ground that he had paid great attention to the strength of materials. No dispute exists, we believe, as to the extent of Mr. Fairbairn's co-operation—at any rate it is fully enough acknowledged in this book - it is only as to the nature of it. Mr. Fairbairn has set up the claim of being joint-engineer in the production of the bridges; but even on the technical grounds he has put forward, we cannot see there is any justice in this, or the assumption that his name should therefore be joined with Stephenson's on the bridges. We say, we do not admit even the technical grounds of the engagement with Stephenson or the Railway Company; but we do not allow that the question is to be argued on such grounds. Mr. Fairbairn has gone into a court of equity, he has opened the whole matter, and judgment is to be given upon the merits. The question then takes this shape—has Mr. Fairbairn an equal claim with Mr. Stephenson? We think not, because Mr. Stephenson was the originator, and because Mr. Fairbairn was introduced by Mr. Stephenson, and therefore subsidiary.

Looking at it in this light, we go the length of saying that had Mr. Stephenson made any bargain with Mr. Fairbairn for equal honours, he would not have been justified in doing so—he had no right to do so—and he would not have been acknowledged in doing so. The merit and responsibility of the suggestion was Mr. Stephenson's; and on the correctness of the principle it chiefly depended whether it could be carried out. The adaptation of the principle was a tentative process, and it matters little in comparison who carried it out. Mr. Stephenson provided the idea, he marshalled the staff for carrying it out, he procured the money for the experiments, and Mr. Fairbairn would have hardly done his duty creditably had he not achieved what he did. Granted there was a responsibility on Mr. Fairbairn—there was upon every assistant—and Mr. Fairbairn well fulfilled his duty, coming in at the beginning; and Mr. Stephenson's time being so fully taken up, the direction naturally fell upon Mr. Fairbairn, and thereby he had the opportunity of doing more than he would under ordinary circumstances; but that by no means raises him to the summit of the hierarchy, though it may advance his position in it. Whatever Mr. Fairbairn may put forward, the original position of Mr. Stephenson remains untouched; and it is hardly worth while to examine the technical grounds on which Mr. Fairbairn attempts to support his case. We are convinced his object is unattainable; and we are therefore the more concerned the controversy should drop, the ill-feeling be allayed, and the former cordiality be resumed.

On Mr. Stephenson requesting Mr. Fairbairn's co-operation, Mr. Fairbairn was officially appointed by the Railway Company one of its engineers, so as to give him the power to supervise contracts; but various circumstances occurred very materially to change Mr. Fairbairn's position. That he went zealously into the work, Mr. Edwin Clark acknowledges; that he freely and liberally acknowledged Mr. Stephenson's origination of the undertaking, his letters show (p. 812); and that he was not knowingly a cause of the subsequent alienation, we fully believe. The taking out a patent for the application of the principle with Mr. Stephenson's concurrence was an effort of Mr. Fairbairn's zeal, but was an instrument of dissension, and the jealousy of Mr. Stephenson's supporters was aroused by representations in the Lancashire papers, that the undertaking was proceeding under Mr. Fairbairn's auspices. When the time came to contract for the work, and Mr. Fairbairn claimed, not unfairly, the lion's share (p. 807), it was a matter of course the Company removed him from the office of engineer, and substituted Mr. Edwin Clark (p. 805). After obtaining a large contract, Mr. Fairbairn resigned it, for a consideration, to Mr. Mare; and this circumstance, together with the heavy charge for the experiment, seems to have created an unfavourable feeling with the Railway Company. Mr. Fairbairn was thus in the end neither engineer nor contractor; and though he gave his co-operation to the last, it is easy to understand how an alienation of feeling arose, and a disappointment, which reacted in his requiring a greater consideration for his claims than either Mr. Stephenson or his friends were willing to acknowledge. Let it be hoped, nevertheless, that the handsome recognition of his services in this volume may be considered as a proof of kindly feeling to which he will reciprocate.

PICTURE GALLERIES.

Can the characteristic forms and decorations of classic architecture be retained in modern buildings without deviation from their original constructive purposes? It is replied that the restriction of primitive forms to primitive uses can be complied with in no other edifices than those constructed on the type of ancient temples.

If this objection were valid it were idle to contend longer for architectural truth, for our advocacy would reduce us to this dilemma—we must either give up the use of classic forms altogether, or we must make all modern edifices in which they are employed similar to the Madeleine at Paris, mere copies of ancient structures. The objection, however, amounts to this, that the rules of Greek architecture are so strict as to be incapable of consistent application to any but a rectangular peripteral building. We concede at once that pointed architecture is infinitely more susceptible of variation than the rival style, from the simple reason that arch-construction remove from the former style the restrictions which in the latter limited the distance of inter-spaces to the length of a single block of stone. But in truth, classic architecture, even in its ancient simplicity and purity, admitted a diversity of construction which suffices to relieve us from the second horn of the dilemma above stated. The exquisite circular temple at Tivoli, and the atria of several houses at Pompeii, are among instances which might be cited of an application of the forms of Greek architecture, with perfect architectural truth, to buildings of which the plans entirely differ from those of the great Athenian temples.

The Berlin Gallery of Pictures must be regarded as one of the most successful instances of similar adaptation in modern times. This edifice presents a magnificent façade of eighteen fluted Corinthian columns, supporting an entablature and the flat roof of a portico which extends the whole front of the building. There is no pediment or other superstructure above the horizontal line of the entablature, but a higher roof rises at some distance behind it from the centre of the building, and is crowned at the corners by bold equestrian groups in bronze, which stand in admirable relief against the sky. The magnificent effect of the portico is further enhanced by the noble flight of steps by which it is approached; and the columns appear the more prominent from the wall behind them being richly decorated by deeply-coloured frescoes.

The light is obtained from the roof and side windows. The latter are not decorated by the ridiculous mimicry of pediments, which is nearly universal in England. There is not a sham-pediment nor a sham-column in the whole Berlin Gallery.

The arrangement of the interior is admirably adapted for the exhibition of its treasures. The Picture Gallery consists of a centre range of compartments, with suites on either side at right angles to it. The whole of this gallery is under one roof, and forms in fact one apartment, but it is divided by screens, extending from the wall between each two windows, to about three-fourths the height and width of the gallery. The pictures are arranged systematically, according to the several schools of painting; the collection of sculptures is contained in three noble apartments below the picture gallery.

The Glyptothek, or Sculpture Gallery of Munich, exhibits the adaptation of classic architecture, with nearly the same constructive propriety as the edifice above described. The characteristic feature of the Glyptothek is its pediment, which however is not fixed against a blank wall for unmeaning ornament, but is the real gable-end of a real roof. The tympanum is richly adorned with sculpture, and the entablature is supported by a double range of Ionic unfluted columns. On either side of the central pile are wings, having distinct and lower roofs. The great defect of the building is the surface of blank wall which is displayed by these wings, and which is only imperfectly relieved by pilasters and niches, surmounted, unhappily, by minature pediments. Exactly opposite the Glyptothek is the School of Art and Industry, resembling it in the main features of a central portico and side wings, but far superior in its general effect. For in the latter building the pediment is loftier, and supported by magnificent fluted Corinthian columns. The wings are without the objectionable pediments, and the blankness of the walls is far more perfectly relieved than in the Glyptothek, by regular ranges of bold pilasters.

The Pinacothek, or Picture Gallery of Munich, is chiefly admirable for its interior arrangement and decorations. The front somewhat resembles in form, though it greatly exceeds in size, the river front of Trinity College, Cambridge; and both buildings have the common defect, that the space occupied by windows bears too large a proportion to the rest of the exterior surface. Here, as at Berlin, the pictures are systematically arranged according to their schools, but the classification is even more perfectly effected. The gallery consists of a continued range of nine halls, communicating by central doorways, through which a vista extends the entire length of the building. There is a parallel range of cabinets, or smaller apartments, each of which communicates directly with its adjacent hall, and contains the smaller or cabinet pictures of the same school and epoch as the larger works in the hall adjoining. The spectator who visits each hall and its appendant cabinets in due succession, progresses gradually from the earliest German school of Albert Durer and Van Eyck to the perfect development of Italian art, in the works of Carlo Dolce, Titian, and Correggio.

The Dresden Gallery as far exceeds in extent the galleries of Munich and Berlin as do these that of London. And yet this most wonderful collection is housed in a building nearly as ugly as our own National Gallery. The arrangement of it for the purpose of exhibiting its treasures is however immeasurably superior. The gallery is contained in a square building, with an inner court; and is there of the form of a hollow square, which is divided into two others by a quadrilateral partition, nearly midway between the inter walls and the sides of the inner court; so that there are two quadrilateral ranges of apartments, one within the other.

Here are none of the gorgeous architectural decorations of Berlin, or the elaborately tesselated floors and richly gilded ceilings of Munich; but the plainness of the casket is amply compensated for by the richness of its jewels. A lover of art unaccustomed to that profusion of pictorial wealth which Italy alone possesses, views with amazement the enormous number of masterpieces which the capital of the little kingdom of Saxony possesses. The *Madonna and Child* of Raphael attract homage, which is not the mere hypocrisy of dilettanti-ism: there is a secret magic in the picture, which rivets the attention of the humble artisan and simple countrywoman. It is before that picture that the greatest throng is seen, when on Sundays the gallery is most accessible to the poor and illiterate; for in Dresden picture-seeing is considered a more suitable occupation for the populace on Sunday than dram-drinking.

Whole rooms-full of master-pieces of Titian, Correggio, Rembrandt, and Rubens; perfect specimens of every variety of art, from the minute Flemish pictures of low life to the loftiest of Italian representations of history; from the sweet simplicity of Murillo's peasants to the proud dignity of Rembrandt and the luxury of Titian; the tranquil sunset of Claude and the wild storm scene of Salvator Rosa—all are there. The eye becomes at last sated, not wearied, with the beautiful; and yet even when his powers of attention have been exhausted, the stranger feels reluctant to turn away, for the mere consciousness of being among the noblest efforts of genius and art is a fascination to him.

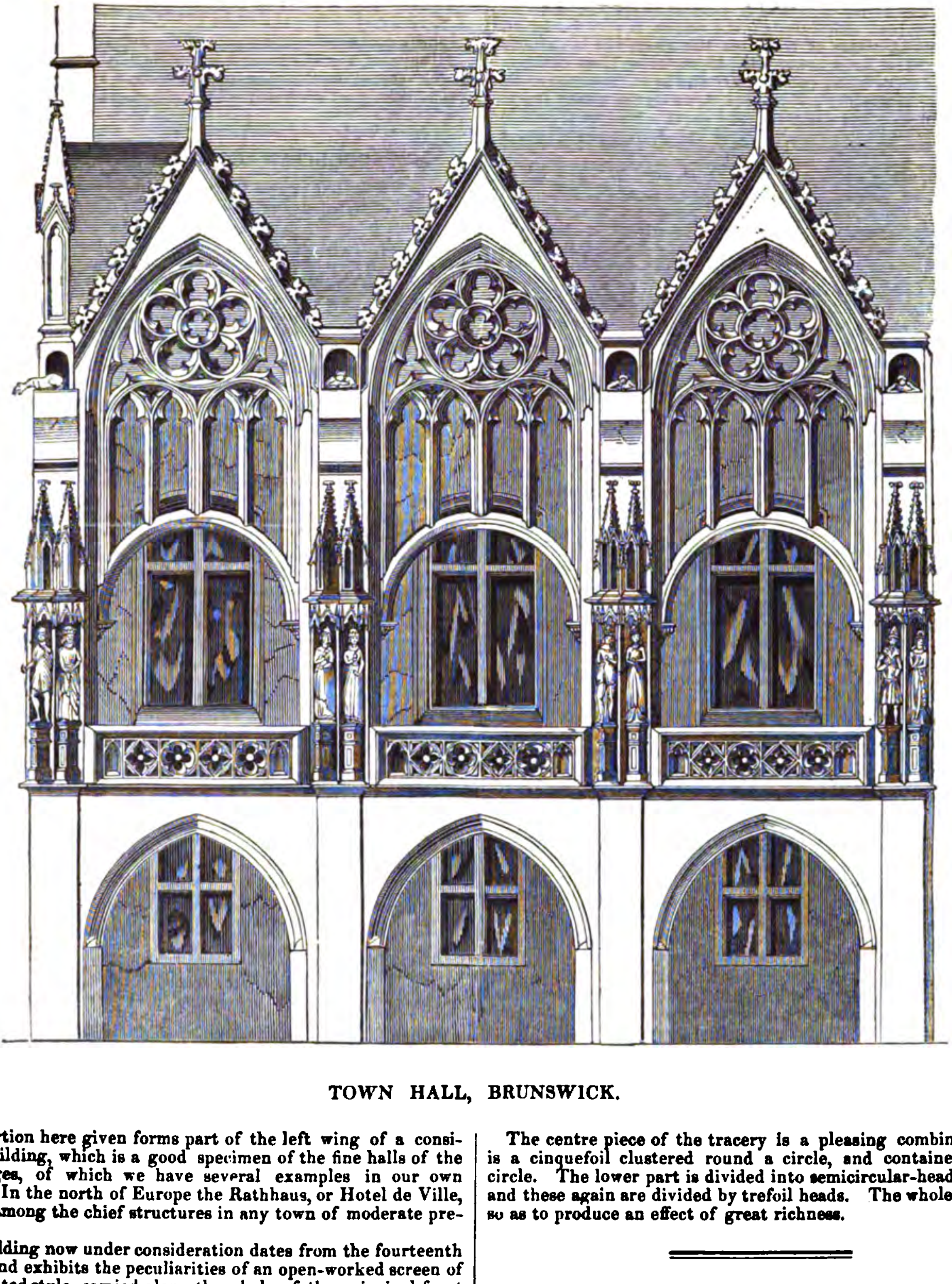
It is with a feeling of humiliation and painful regret that we turn to the degradation of art in the largest capital in the world. What insufferable sordidness and perversion of taste are concentrated—quintessenced—in our Trafalgar Square! Not to speak of the "hideous absurdities" dotted about it—the contemptible fountains and monstrous column! what but inevitable necessity or a long education in the rules of bad taste could reconcile us to the pile in which our scanty store of pictures is huddled? One half the building, wretched as it is, is not our own, but given away to a company whose traffic in an annual raree-show debars the nation from enlarging its collection by purchase or private munificence, and compels the crowding what pictures we have, without system or method, half out of view, into ill-ventilated, ill-planned rooms, or dark underground cellars.

It has been objected to the extension of the national collection, that a general taste for art would render the people effeminate and ultimately licentious; and we are referred to those ages and nations which have been most devoted to art, as examples of extreme profligacy. Let us concede that licentiousness and professed love of art held sway in the court of Louis XIV.; the art was as licentious as the morals of the court, the offspring not the parent of luxury. An idle, self-indulgent people like the Italians, will encourage painting among other sources of enjoyment; a pleasure-taking Bavarian monarch recreate himself in adorning his capital. What then? does it follow that because vice encourages art, art encourages vice? By no means; for in all instances which can be referred to on the subject, the element of self-indulgence already exists precedent to the encouragement of art. But to show that such encouragement has itself a vicious tendency, it would be necessary to cite instances of its producing corruption where none previously existed. Such instances are wanting. On the contrary, we see the honest, true-hearted Germans devoting themselves to music without losing their simplicity of manners (excepting in those capitals where independent causes of contamination exist); the hard-working Flemings retaining their industry amidst the unparalleled fertility of their school of painting.

The English are eminently a hard-working people. The peasant works hard a-field, the country gentleman at sessions; the mechanic toils at the loom, the duke at public business, and our very sports are severer labour than the daily toil of other nations. We rise up early, and late take rest, and eat the bread of carefulness. Is there the slightest chance that the occasional inspection of a picture gallery will destroy this element of the national character, and render the people inert? On the contrary, the necessity for industry is goading them the other way.

The fact is, that all work and no play is making John Bull rather a dull boy. He has not holidays enough, and he does not know how to enjoy those he has. He requires more indulgence than a lecture on carbon at the mechanics' institute, or the evening class for improving his mind after work-hours. If extra indulgence be not granted him of a rational kind, he will find it for himself of an irrational kind in the follies of the casino and horse race.

The British Museum is a growing institution—why should not the National Gallery grow also? The British collection of marbles is not so very far inferior to those of other nations, because it receives constant accessions. Even within the last year or two, its additions have been extensive and valuable, and the expense of them is reimbursed by the nation ungrudgingly. But the collection of ancient masters of painting makes no progress, simply because there is not room provided for more pictures. To allege that no more *chefs d'œuvres* are obtainable because they are all secured for other collections, is to ignore the fact that within a comparatively recent period a large and invaluable collection was disgracefully lost to this country and deposited in the Louvre. Such opportunities, once neglected, seldom recur; but others of a minor nature still occasionally offer themselves, and a vigilant administration of the National Gallery, together with increase of room, might still render a respectable collection possible. On the principle that any building is better than none at all, an incessant din ought to be kept up about the ears of government, until the half of the present Gallery of which the public has been so long defrauded, has been restored, or the whole enlarged by an upper story. Such a superstructure, if designed with taste, would remove several elements of the hideousness of the present building. The disproportion of the length to the height would be mitigated, and we might even dare to hope that the sham dome would disappear. The pile might be made to look better—we know that there is no fear of its being made worse; and even if all its worst features were retained—why the English are so disciplined in the school of deformity, that they would submit to the infliction with exemplary resignation.



TOWN HALL, BRUNSWICK.

The portion here given forms part of the left wing of a considerable building, which is a good specimen of the fine halls of the middle ages, of which we have several examples in our own country. In the north of Europe the Rathhaus, or Hotel de Ville, is always among the chief structures in any town of moderate pretensions.

The building now under consideration dates from the fourteenth century, and exhibits the peculiarities of an open-worked screen of the Decorated style, carried along the whole of the principal front of the building. This is of a particularly pleasing character, and shows considerable ingenuity in design, and freedom in execution. The tracery in the head of each compartment is carried on a semicircular arch, and the heads of the windows are likewise circular. The details are executed in much the same manner as those of the corresponding period in England; and the statues in the niches are those of the reigning dukes and duchesses of Brunswick. A similar arrangement is sometimes found in the cloisters of cathedrals and conventual buildings.

The centre piece of the tracery is a pleasing combination. It is a cinquefoil clustered round a circle, and contained within a circle. The lower part is divided into semicircular-headed arches, and these again are divided by trefoil heads. The whole is treated so as to produce an effect of great richness.

SANITARY MEASURES.

In another column will be found the report of the Sewers Commission on the amended plan of drainage they now propose for the metropolis. This speaks for itself, and we need not describe it; but we are glad to find that the Commissioners have attended to the voice of the press, and that one important object is secured—the non-pollution of the Thames in its course through the metropolis. The nuisance of the sewers has become so great that it can no longer be borne, had Sir John Burgoyne or any other of the

Commissioners persisted in upholding it. The Thames is now so much used in summer-time for short, or, as it may be called, omnibus traffic, as to make it highly needful to keep it free from poisonous influences. All through the season Hungerford-pier, one of the greatest places of traffic on the river, has been made an annoyance, as a large sewer discharges its noxious contents over the mud-flats reaching to the pier; and as the steamboats lie for a short time at the pier and are low down on the water, the ill effect to the passengers must be very great. Besides the usual abominations, this sewer seems to carry the drainage of a graveyard.

Whether the sewer water will be of much good in Woolwich or Erith marshes, we very much doubt. Sewer water, water charged with carbonate of lime, or any water, is a good fertiliser; but the expense of distribution, and the relative smallness of the area supplied will prevent any great results being obtained from the reservoirs in the marshes as compared with the quantity of fertilising matter collected from the metropolis.

In our late visit to Edinburgh, we made particular inquiries as to the working of the supply of sewage water there, which has been so much spoken of among agriculturists and professional men. We were informed that the sewage water is not so valuable for meadows as for market gardens; and we apprehend the same results will be found in Woolwich and Plumstead marshes, where the quantity of market-garden ground is very small. The value of grass land near Edinburgh is raised by the distribution of the sewage water; but the grass is found to be very rank. In another point of view, the application of sewage water is found highly objectionable, for whereas the aggregate agricultural benefit is small, the dispersion of the sewage water constitutes a fearful nuisance. When the wind at Edinburgh blows from the east over the meadows, it brings the most noxious odours; and this must be the case to the inhabitants of Greenwich, Woolwich, Deptford, and our eastern suburbs, if sewage water is used in the marshes. Thus all the usual evils of an easterly wind are aggravated.

Not only is the sewage water an annoyance to the people of Edinburgh, but it is said to be a cause of disease to those living in the neighbourhood of the meadows, so that many are in favour of introducing the Health of Towns' Bill, in order to have power of grappling with the nuisance.

While we are pleased with the prospect of the purification of the Thames, we cannot help feeling that much remains to be done in a sanitary and economical point of view. The entering of the waterclosets into the sewers has converted the sewers into a much greater nuisance than they used to be thirty or forty years ago, when no entries from waterclosets were allowed to be made. The introduction of fecal matter into the sewers brings noxious gases into the houses, and the water which is spent for washing the waterclosets acts to decompose the fecal matter. The waste of water is not the only economical loss, for there is a waste in London of a quantity of manure which would be equivalent to the growth of at least three million quarters of corn. While this fecal matter is sent into the sewers, neither large nor small sewers will work satisfactorily.

How this is to be remedied we are not prepared to state; but we think the attention of architects and engineers should be turned to the subject, with the view of determining on the best means. Several parties have proposed dry closets here; but we are given to understand that mainly through the exertions of M. Gauthier de Claubry, a member of the Council of Health at Paris, a system of dry closets, with the application of deodorising substances, is extensively and satisfactorily applied at Paris; and that under the direction of joint-stock companies, very valuable manures are prepared for agricultural purposes, yielding a large profit. This system of *fosses mobiles* will be found briefly explained in Weale's Dictionary of Terms.

Sewage water can only be applied to a restricted area, as the Edinburgh meadows or Woolwich marshes, and it will not pay for transmission to a distance; but solid manures can be sent even to the Indies, and admit of distribution over a wide extent of country. A ton of solid manure is of some value, and will pay for transit; but a ton of liquid manure is worth little more than a ton of water. The economical end to be obtained is, therefore, to get the manure in a solid form; and on every ground, if practicable, it is desirable that it should be collected at once, and not be washed with water, and then separated at an expense. It has been supposed that deodorising compounds lessen the fertilising properties of manures, though it is asserted by M. Gauthier that the system adopted at Paris and Lyon is found by experience not to be prejudicial. However it may be, the operation of water on night soil is decidedly objectionable.

At Paris the night soil is not being washed into the sewers, and in preference, they are emptying the cesspools by the pumping apparatus; but even then, instead of doing as our Commissioners of Sewers do, turning the night soil down the nearest drain, it is carefully conveyed to the works of the manure companies.

It appears, therefore, most desirable that the attention of all parties should be directed to the sewage system, with a view of accomplishing satisfactorily all the objects desired.

METROPOLITAN COMMISSION OF SEWERS.

At the last monthly general Court of Commissioners on the 9th ult., at the central office, Greek-street, Soho, the first portion of the general plan for the drainage of the metropolis was brought forward.

Mr. Woolrych, the secretary, explained an important error that appeared in the public reports of the proceedings at the Metropolitan Court of Sewers, held on the 28th of February, an error which has a material bearing upon the observations made upon the general conduct of the business of the commission. The item in question is thus described:—'Payments for *books*, surveys, management, &c., 85,346*l.* 3*s.* 6*d.*' The error alluded to consists in the use of the word *books* instead of *works*, the item being described in the accounts presented to the court as payments for works, surveys, management, &c.

The Drainage of the Metropolis.

The committee appointed by the General Court to take into consideration the general drainage of the metropolis, and report thereon, determined to divide their labours into three distinct portions, or rather three distinct reports; *the first* to consist of a plan for the drainage of the southern side of the Thames; *the second* to consist of a plan for the drainage of Westminster; and *the third* to be a plan for the general drainage of the metropolis north of the Thames. The committee determined to take the drainage of the southern portion first into consideration, as its requirements seemed to them to be more immediately pressing than those of any other district.

The following is the engineer's report on the Surrey Drainage:—

"In obedience to instructions which I had the honour to receive from you on the 8th ult., I now proceed to furnish a report and estimate for a complete system of drainage for the Surrey and Kent districts, including extensive alterations in the inclination of existing sewers.

"Notwithstanding the labour and ingenuity displayed in many of the plans for the drainage of the metropolis sent in last year—some of which, as you stated in your report of the 8th of March, dealt ably with the general drainage on the north side of the Thames—I have been, as you are well aware, in laying out the plan of drainage for the south side, able to derive little or no practical assistance from any of them, which is to be accounted for, doubtless, by the necessarily defective data on which they were based, owing to the imperfect nature of the information which it was then in the power of the commissioners to supply to their various authors; but I feel it my duty to acknowledge in the outset the very valuable assistance I have received from plans and suggestions prepared, after consulting the block plans and subterranean surveys, by a member of your honourable commission, who kindly placed them in my hands during the preparation of the plan I have now the honour to submit.

"In drawing up this report I have, under your instructions, adopted the following principles for my guidance:—

"1. To keep the River Thames free from sewage at all times of the tide from Woolwich-reach upwards.

"2. To abolish all open ditches and cesspools, as well as defective, shallow, or high level sewers.

"3. To maintain a continual and unintermitting flow, with the aid of lifts where necessary, in all the sewers along their whole length, by which the evils arising from pent-up sewage—viz., the generation of noxious gases and the unavoidable formation of deposit in the sewer during its stagnation—may be avoided.

"4. To construct the sewers at inclinations so proportioned to the volume of fluid to be carried off by each that the velocity of the current shall keep them clear of deposit without the need of regular periodical flushing, which experience has shown to be not only troublesome and expensive in its operation, but also very injurious to the sewers and drains in which it is practised.

"5. To form the main sewers at such a depth as not only to receive the drainage of the deepest existing sewers, but to answer the purpose of main drains capable of extension towards the extremities of the district.

"6. To provide a natural escape by the power of gravity alone for storm waters and land floods independent of the ordinary sewers, whose contents will on the south side of the Thames require artificially lifting, and to construct the new sewers of such sizes only as may be sufficient to take the general drainage of the district, including ordinary rain falls connecting them at about mean low water, with outlets for heavy floods.

"7. To follow existing public streets, roads, or paths, so as to avoid heavy compensation for injury to private property whenever this can be done, without causing injurious curves or undue prolongation of the sewers, and consequent loss of level.

"8. To extend the ramifications of the sewers after the main lines are completed into all the streets at such depths and with such inclinations as to give perfect self-cleansing street drainage, and the opportunity for efficient house drainage.

"The following is a general outline of the means proposed to effect the objects abovenamed:—

"I beg to recommend the top of Woolwich-reach as the point for delivering the sewage into the river, because I believe that the matter so delivered at and after high water, and in the centre, and at the bottom of the stream, will not rise to the surface, so as to inconvenience the inhabitants of Woolwich. If, however, it should be deemed expedient, either for agricultural purposes or for any other reason, to convey the sewage below Woolwich to some point near Erith before its delivery into the Thames, it may be effected by means of iron pipes across the marshes and through Woolwich, to be supplied by an engine and standing-pipe erected at or near the Woolwich-road, near Greenwich-gate.

"Commencing with the outlet at a point 8 miles below London-bridge, it is proposed to form a double reservoir capable of holding at least 24 hours' drainage, covered over, and elevated to such a height as to discharge the whole of its contents at high water, delivering them by means of pipes near the middle and at the bottom of the river. The sewage will be lifted into the reservoir at this point (by means of an engine) from the main sewer, the invert of which is proposed to be at about mean low water, and 10 feet below the surface of the marshes.

"Hence the course of the main sewer will be across Greenwich marshes, along Woolwich Lower-road, Trafalgar-road, and Roan-street, to the Ravensbourne (where there is proposed to be a lift not exceeding 25 feet); passes under the River Ravensbourne past the corner of the Trinity Almshouses, crossing Union-street and Bridge-row or Collier-street.

"This lift and shaft I propose to place completely under cover, and to connect with the chimney of the smoke-consuming furnace of the engine all the passages from which any gases could escape from the sewer, and I feel perfectly confident that with these precautions the possibility of any annoyance being caused to the neighbourhood may be obviated.

"I mentioned above that it was not proposed that the engines should have to raise all the storm waters or land floods; these will be provided for in extraordinary cases by the four existing outlets—viz., the Effra, the Earl, the Duffield, and St. John sewers, and by means of reservoirs and a diversion of the upper part of the Effra to keep the low-lying and thickly-inhabited part of the district free from floods.

"From Collier-street a line which may by called the 'southern main line' diverges: the 'northern main line' passing along the Lower Deptford-road to the crossing of the Earl sewer, from which point it strikes into a north-westerly direction, and in a straight line towards St. James's church, Bermondsey, thence along Prospect-place to Dockhead, and thence to Gainsford-street and Tooley-street, where it unites with the great St. John's sewer, with which are connected the Battle-bridge and its various branches; the inclination of the new sewer for the whole distance being at an average rate of about 4½ feet per mile, somewhat less near the point of discharge, somewhat more of course as the volume of fluid diminishes at each successive ramification of the sewers.

"Returning to the diverging point at Deptford, the course of the 'southern main line' will be by Loving Edwards'-lane nearly in a straight line with Old Kent-road at Hatcham, along the Old Kent-road to Surrey Canal-bridge, which is at the point of divergence of an intermediate main line to be afterwards described; the southern main line will proceed by Neat-street and Albany-road in a straight line across to St. Mark's-road, and by Camberwell New-road to St. Mark's Church, Kennington. Here it will pass under the Effra sewer and by a connection therewith will receive its ordinary run of drainage; the floods of the Effra being provided for by a relief line about 1200 yards long, passing along the Oval and Harleyford-street to Vauxhall-creek—the present open and most offensive portion of the Effra from Kennington-road to Vauxhall being filled-up and abolished.

"The level of the southern main line at St Mark's Church would be about 1·0 or nearly 7 feet below the deepest sewer existing there at present, and will afford unexceptionable drainage for Stockwell and Clapham, Balham-hill, and the whole district lying between Brixton-road and Wandsworth-road.

"The course of the 'intermediate line,' diverging at the Surrey Canal-bridge, proceeds along the Old Kent-road to the Bricklayer's Arms, where it will divide: one arm passes along the New Kent-road to the Elephant and Castle, where it will receive the drainage of the Walworth and Kennington roads and a portion of London-road and St. George's-road.

"The other more northern arm of this intermediate sewer proceeds from the Bricklayers' Arms along part of the Dover-road and Trinity-street, crosses Blackman-street, continuing along Great Suffolk-street across Southwark-bridge-road, along Suffolk-street, across the end of Gravel-lane, through Nelson-square, to Rowland Hill's chapel, at which point its level will be 0·40, being about 1 ft. 2 in. below the Battle-bridge sewer. This intermediate main line will be 2½ miles in length from the Surrey Canal bridge to Rowland Hill's Chapel—one-half of it through streets at present without deep sewers, and one-half along the line of an existing deep sewer, for which it will form a substitute, and the more southern arm passing up to and dividing at the Elephant and Castle, about one mile in length, along the lines of existing sewers. The inclination of the proposed new lines varying at the different parts of the sewer according to the branches received on the principle above mentioned.

"Consequent upon this intermediate main line being carried into the middle of the populous districts will be an alteration of the levels of above six miles of existing sewers in the following streets—viz., New Cut, Cornwall-road, Waterloo-road, Borough-road, Newington-causeway, Westminster-bridge road, Lambeth-road, Westminster-road, parts of London-road, and St. George's-road. This will involve in addition much alteration in secondary drains and in house drainage; and I cannot quit this part of the subject without again suggesting to the commissioners the expediency of watching and testing the working of the present main drains as soon as the main sewers are sufficiently completed to do so, before they proceed to the extensive alterations in the existing sewers which the contemplated interference with them will involve.

"I beg now to lay before you my estimate of the cost of draining the district according to the system above described; but before doing this I would observe that in drawing up this report and these estimates, I have thought it desirable to put down the outside amount of lift, of depth of drains, &c., in order that if there be any error it may be on the right side. In this estimate I have neither included compensation for passing through or under private property, which, however, from the lines adopted in accordance with the principle you laid down, will be comparatively trifling, nor the cost of the detailed drainage, to estimate which will be a work of much time and lengthened inquiry. In any case this will involve a considerable outlay, but as it is dependent on the settlement and partial completion of the main drainage, it would have been premature to go into it here; neither have I taken into account the cost of extending the system of drainage into the suburban districts—a provision which it becomes daily more imperative to make.

Estimates of cost of system above described.

	Miles.	Fur.	Cost.
Main trunk drain from outlet in Greenwich marshes to the left at the Ravensbourne	2	0	£25,587
Reservoirs and outlet-pipes			20,280
Pumping engines and apparatus			27,400
From the left at the Ravensbourne to a point near St. James's church, Bermondsey, north main line	2	5	46,930
Extension of north main line from St. James's church to the Great St. John Sewer	0	6	8,000
South Main Line from Collier-street, Deptford, to St. Mark's church, Kennington	4	0½	49,600
Flood line of Effra	0	5½	7,200
Intermediate main line from Surrey-canal bridge, with northern arm to Rowland Hill's chapel	2	2	12,000
Southern arm along New Kent-road	1	0	5,000
Alteration of existing sewers to connect with the intermediate main line, &c.	6	0	32.000
Effra flood line diversion by Peckham			7,000
	19	8	£241,297

"1, *Greek-street, Soho, 1st August*, 1850.

"FRANK FORSTER.

"To the Hon. Metropolitan Commissioners of Sewers."

Mr. STEPHENSON, at the conclusion of reading the report and in moving its adoption by the Court said—"I think it desirable to explain to the Court a few of the principles which actuated Mr. Forster in devising the plans which are now upon the table, and the reasons which guided him in laying them down. Before commencing the consideration of these general principles, however, allow me to say, in reply to some complaints which have been made out of doors respecting the great delay which has taken place in proposing any general plan for the drainage of London, that the public must bear in mind that the commission has not been more than 10 months in existence, and that some of its members came into it quite fresh—unacquainted with a great number of the localities of London, and absolutely unacquainted with the complicated system of sewage existing, to the extent of nearly 600 miles. In addition to this, the underground surveys were in a very incomplete state, and no one could venture to say what general plan ought to be pursued at that time, as it was dangerous to commence with any one locality, for fear of interfering with the ultimate chance of success. London, however, divides itself naturally into two districts — north and south, and after the commission had examined generally the condition of these two districts, they found that Bermondsey, Lambeth, and Southwark were infinitely worse than the north side; to that portion, therefore, they have directed their attention, almost without cessation, during the last few months. I am glad to see these plans upon the table of the Court, having in view the establishment of a complete and perfect system of drainage for this district, which extends over nine square miles, three of which are from 6 to 7 feet below high-water mark. The whole eight or nine square miles vary from 2 to 6 feet under high-water mark. It will be apparent that to devise a system of drainage for this locality is a work of no inconsiderable difficulty. The locality may be said to be drained only for four hours out of the 12, and during those four hours only very imperfectly. The sewers now empty themselves into the Thames at various levels, and when the tide rises above the orifices of those sewers, of course the whole drainage of the district is stopped until the tide recedes again; thus the whole system of sewers in that locality may be said to be but an articulation of cesspools. The commission commenced the consideration of this subject with a sincere desire to accomplish the drainage by natural means, if possible; but it soon became apparent that these sewers, which were subjected for eight hours out of the twelve to a state of stagnation, acquired a settlement of solid matter which required even a more extensive system of flushing than that which we now possess. It has been proved by the last few years that even flushing, under such circumstances, is not efficient, and the tendencies in these sewers to form a concrete of hard substances is such as to render any current of water, however rapid and constant, quite ineffectual. Under these circumstances it became apparent that the commission must resort to artificial means of drainage, and pumping by steam appeared to be the most economical and the most efficient plan. Mr. Forster therefore proposed the establishment of a steam-engine at the Ravensbourne to lift the whole of the sewage of the district to a height of 20 feet, and by that means a current would be established so as to maintain throughout the whole day, without cessation, a constant flow, and the solid matter which now forms the subject of complaint would be carried off. The expense of pumping may at first appear to be very great. I thought so myself at the commencement; but when it was reported to me by the officers of the commission, that the cost of flushing and the cost of removing this solid matter now concreted at the bottom of the sewers would be very great, and that the cost of pumping-up the whole of the sewage matter would cost less money, I thought that the system of pumping, as applied to the south side of the Thames, appeared to be entirely without objection. I will not now go into the details of the works, as Mr. Forster has already explained them; and I shall move that Mr. Forster's report be adopted, and that the works therein recommended be carried out forhwith."

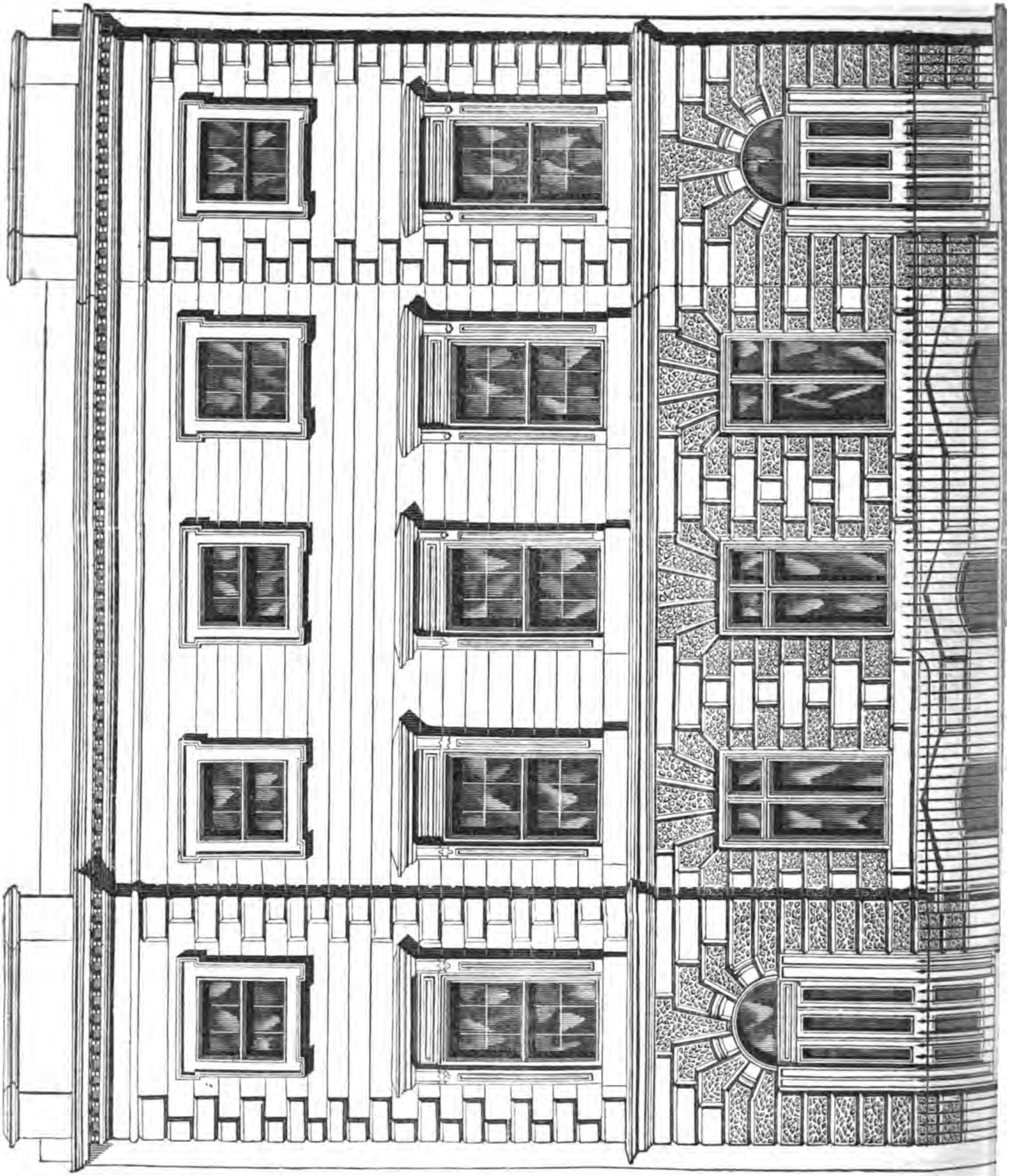
Sir JOHN BURGOYNE said: After the clear and full statement made by Mr. Stephenson, it is not necessary for me to go into any of the matters or details connected with this report, as it would only lead to confusion. It is, however, satisfactory to know that, after the consideration given to these general principles laid down in Mr. Forster's report, the commissioners are unanimous in adopting them; and that, with regard to details, there is no difference of opinion amongst us. I think that no dissatisfaction can be expressed by the public at the system which we propose to adopt; and I am glad to have an opportunity of expressing my own full concurrence in the report which has just been read.

The CHAIRMAN: The Court has at last succeeded in coming to a satisfactory solution of this very difficult question, and I was never more rejoiced than I am now to find that we have substantially brought it to a conclusion. I must remind the Court, however, of clause 17 in our act, which provides that no law shall be considered formally enacted by any court unless notice is given of it previously. I think, therefore, that we had better consider this day's proceedings merely as the required notice, and formally adopt this report at a future special court.

This was agreed to without remark.

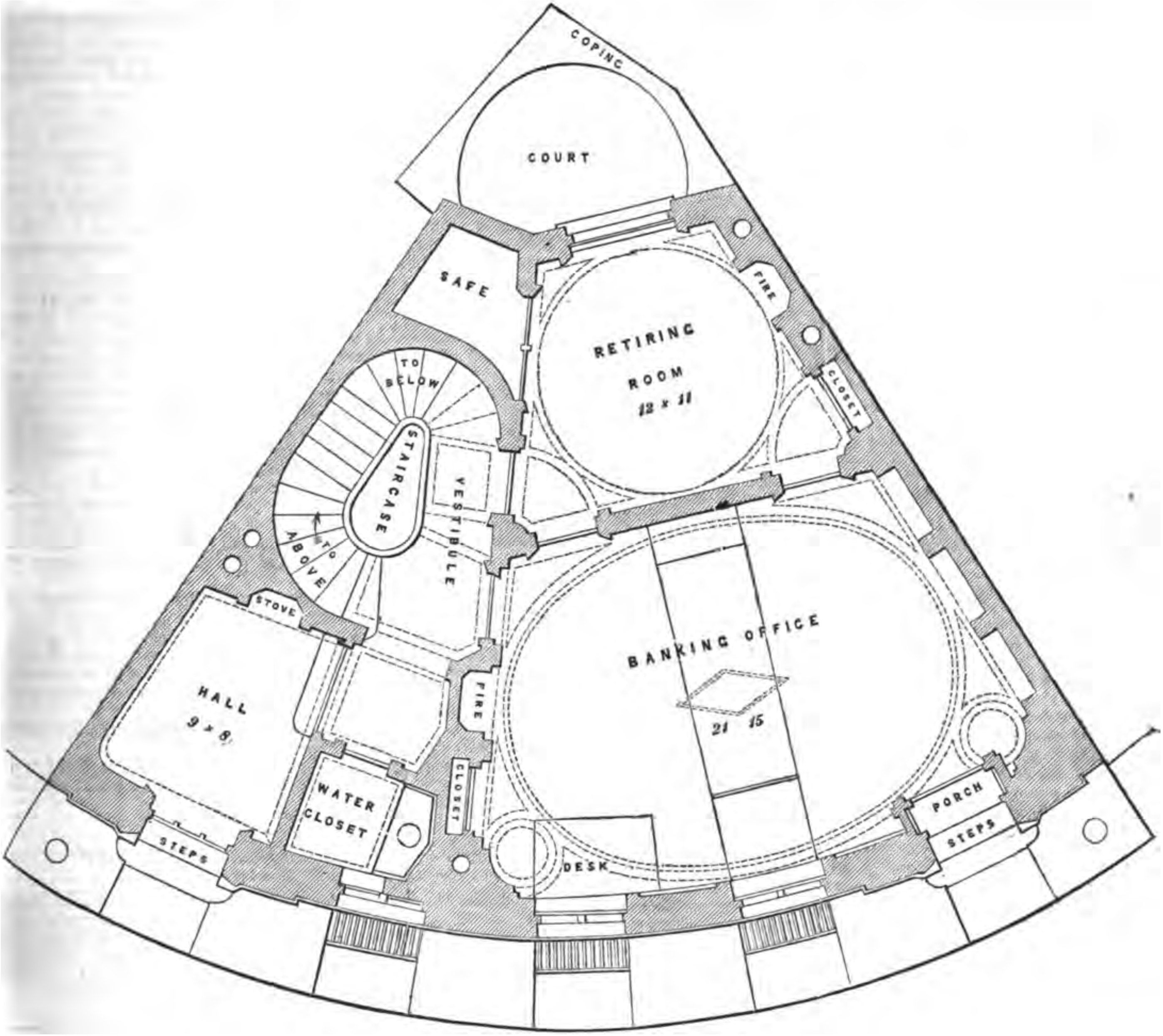
Mr. HAWES said: In reference to the prompt execution of these works, we are now in treaty with several persons for the loan of sufficient money to carry them out. We shall require about 250,000*l.*, to be repaid in 30 years by 30 instalments, principal and interest. The expense so divided will amount to about 2*d.* in the pound.

Mr. HAWES, in answer to a question whether it was compulsory upon landlords to drain into these sewers when they were formed, said, the Act compelled every house within 100 feet of a sewer, to drain into it; and care would be taken to have a sewer within 100 feet of every house.



THE WHITBY BANK.

J. B. & William Atkinson, Architects.



GROUND PLAN.

Scale of Elevation.

Scale of Plan.

THE Whitby Bank is a very good example of a small branch bank in a district yielding stone. Such a building requires accommodation for the residence of the officers, and consequent safe custody of the property, as much as room for the business. Indeed, the banking office need not be very large, either for clerks or customers, in a small town. A branch bank must bring its staff within close compass: the manager is likewise clerk and custodian, and it is found economical to provide him with a residence. It is otherwise where the banking business is very large, for there the domestic part of the building is small, and there is more opportunity for architectural display, and a large hall becomes the distinctive feature.

The arrangement of the Whitby Bank is peculiar, and will be interesting to our readers, who will see what the architects have been able to do with an ungainly site. They have, it will be seen, given to their front a curved sweep, which has the effect of communicating to it a peculiar and marked character. In the interior the banking office is irregular on the ground plan, but the ceiling is elliptical; and the retiring room behind it, likewise peculiar in shape, is made symmetrical in the floor and the ceiling.

The building is of stone procured from the neighbourhood, and the dressings of the doors and windows are rusticated. The windows are for safety provided with Bunnett and Corpe's iron revolving shutters, and the safe is under the counter, and descends into a vault in the fire-proof basement. The safe is moved up and down by an hydraulic pump, and it contains all the cash drawers and the bank books. When down in the vault an iron door closes all. The total cost of the building and fittings was 1600*l*.

The architects were Messrs. J. B. and William Atkinson, of York.

PHOTOGRAPHY.

Photography on Gelatine:—Means of obtaining very clear and very Transparent Negative Proofs, capable of being transferred a great many times on ordinary Photographic Paper. By M. A. Poitevin.*

In order to prepare the layer of gelatine on which I make my negative proof, I dissolve in 100 grammes of water 6 grammes of gelatine of good quality (that which is met with in commerce, and which is used for preparing jellies for food succeeded best). This size should not contain salts soluble in water; it should also be as free as possible from fatty matters. To make the solution, I steep the gelatine in distilled water for 10 or 15 minutes; I slowly heat over a spirit lamp, and agitate continually until the solution is complete. If any scum forms, I carefully remove it by means of blotting paper, which I draw over the surface; I strain it through a very fine cloth, previously damped, and I again skim the surface on which a few striæ form, arising, doubtless, from fatty matters which escape the first skimming.

The gelatine being thus prepared, I take, with a graduated pipette, a determinate quantity, and I run it over a very even plate of glass placed horizontally; a layer of 1·50mm. is sufficient; this quantity is equivalent to nearly 20 centimetres of solution for a surface of half a plate having 13·5c. or 17·5c. A thicker layer would not be injurious, but a thinner one might present some inconveniences.

Before running the gelatine on the glass plate, a thin layer is applied to it by means of a cloth impregnated with a solution of gelatine, rather more dilute than the foregoing; afterwards, the glass plate is gently heated by means of a spirit lamp; then the solution of gelatine is run on, and flows uniformly over the plate. The under side of the glass plate is again heated, but with moderation, in order to give fluidity to the gelatine, and is allowed to cool.

The plate being thus prepared, I plunge it into a solution of acetate of silver, keeping the surface covered with gelatine underneath, and inclining it in the solution until the latter has completely moistened it; I then turn the glass plate and immerse it completely in the solution; then I pass a very soft pencil several times, and in different directions, all over the gelatinised surface, in order to dispel the bubbles of air which may adhere to it; and, before withdrawing it, I blow on the surface to ascertain whether the solution has moistened it all over. I then remove the plate, and holding it somewhat inclined, I pass the pencil already used over the whole surface, taking care to cover the edge of the previous stroke with that of the following one. I then dry the under side of the plate, and place it horizontally until the surface is dry, which requires five or six hours.

I ordinarily prepare over-night the plates which I intend to use on the following morning, and in the morning those which I mean to use in the evening. It is important that no free liquid should be left on the surface of the plate when it is required for use, for the preparation would be removed at the places where any remained. This preparation should be made out of the solar light. The plate covered with the solution of acetate of silver should be kept out of the light.

The solution of acetate of silver is prepared by making a saturated solution of acetate of silver, to which half its bulk of water is added. Admitting that 100 parts of water dissolve, at the ordinary temperature, 0·5 gr. of acetate of silver, to prepare 0·750 lit. of the solution which I use, I dissolve 2·5 gr. of acetate of soda in 15 grammes of water; I likewise dissolve 3·03 gr. of nitrate of silver in 10 grammes of water; I add the solution of nitrate of silver to the solution of acetate of soda, and I receive the acetate of silver which is precipated on a filter; I wash the precipitate in a stream of water, then I pass through the filter several times 0·50 lit. of water; almost the whole of the acetate of silver should then be dissolved; I afterwards add 0·25 lit. of water to the half litre of saturated solution.

In this operation 3 grammes of acetate of silver are formed, the 0·75 lit. should contain only 2·50 gr., but I put in a little more of it to make up for any that may have been lost in the water of the solutions and of washing. The acetate of silver being very easily altered by the solar light, I make this solution as far as possible in a dimly-lighted place. I preserve it in a bottle covered with black paper, and filter it every time I use it.

I expose the plate prepared as above described to the vapour of iodine, in the same manner as a plate of silvered copper; only, for this exposure, account must be taken of the time, for we cannot judge of the tint on the surface, only the time of exposure is shorter than for silvered plates. The iodised plate is placed in the frame of the camera obscura, and then I cover the side which is not gelatinised with a piece of card-board covered with black cloth. It is good to allow some time to elapse between the iodising and the exposure to the focus of the camera; the plate thereby gains in sensibility. I have sometimes used plates five or six hours after the iodising; they had lost nothing of their sensitiveness.

The sensitiveness of these plates is about one-fourth of that of plates prepared with iodine and bromine. For a landscape with much light and with an object-glass with a small diaphragm, the exposure in the camera may require from 80 to 100 seconds. Portraits, with strong lights and shades, may be taken in two minutes with the portrait object-glass. I have tried the effect of the vapour of bromine on these plates, and have found that it renders them more delicate. I have not made sufficient experiments to have certain data on this subject.

In order to make the image appear, I plunge the plate into a solution of gallic acid containing 0·1 gr. of gallic acid in 100 grammes of water; I leave the proof until the shadows appear sufficiently intense. This immersion may last an hour or an hour and a half. With a more concentrated solution of gallic acid, it would require a shorter time, but it would be more difficult to regulate its action. At the commencement of the immersion, a positive image is formed on the surface of the gelatine. This image becomes more and more dark; but, on looking through it, the parts corresponding to the shadows in nature remain very light.

To fix the proof, it is washed in ordinary water, and then left for about a quarter of an hour in a solution of 1 gramme of hyposulphite of soda in 100 grammes of water; it is again washed in ordinary water, and it is steeped for the same length of time in a solution of 1 gramme of bromide of potassium, in 100 grammes of water.

I wash the proof with ordinary water, allowing it to remain in it for fifteen or twenty minutes; then I wash with distilled water, and allow the layer of gelatine to dry in the open air. It is then a very clear negative proof, capable of giving positive proofs, with ordinary photographic paper, in the sun, in from 2 to 10 minutes, according to the vigour of the negative proof: it also comes very well in the shade.

It is well to renew, at each operation, the solutions of gallic acid, hyposulphite of soda and bromide of potassium.

In this operation, if the solution of gallic acid be replaced by a solution of sulphate of protoxide of iron, very beautiful positive proofs are obtained.

Photography on Paper.—Means of obtaining the Image in the Camera Obscura on Dry Paper. By M. Blanquart-Evrard.

To render the execution of photography on paper simple, sure, and easy to those least experienced in chemical manipulations, should be the object of the efforts of those who wish to bring this art to its most useful application in industrial economy. The first condition for entering into this new order of things, is to rid the operation of the care which it requires at the time of the exposure. We open the way by giving here:—

1. The means of operating on dry paper, instead of damp paper, freeing the operator from the difficult preparations which he has to make at the places of exposure.

2. So simple a mode of preparing this photogenic paper, that it may be manufactured and sold to the amateur who does not desire the trouble of preparing it himself.

The papers prepared by the means hitherto described could not be brought to the dry state without afterwards taking, under the action of gallic acid, an uniform coloration which would efface the photogenic image, and cause it to completely disappear. Serum has the property of obviating this inconvenience; the following is the mode of preparation to be adopted:—

Collect, by filtering, the clear part of milk which has been turned, and beat up in this serum the white of one egg to each pint, then boil in order to remove all the solid matters, and filter again, after which dissolve without heat 5 per cent. by weight of iodide of potassium. The paper to be prepared must be very thick and steeped entirely in the liquid for two minutes, and afterwards dried by hanging it, by means of two pins, by two of its corners, to a line.

This preparation is made in the daylight without any particular precaution; the paper is fit for immediate use for six months after and certainly after a much longer time. When it has to be used

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* *Comptes Rendus*, No. 21, May 27, 1850.—*Chemist*, July 1850.

it is submitted to a second preparation, which is done by candle-light, and as short a time as possible before the exposure; it is, however, still capable of giving good results several days after, avoiding then, as much as possible, leaving it in a high temperature.

We proceed therefore in this preparation by covering a glass with aceto-nitrate of silver composed of 1 part of nitrate of silver, 2 parts of crystallizable acetic acid, and 10 parts of distilled water. On this substance is deposited one of the sides of the paper, which is allowed to imbibe until it has become perfectly transparent, which is ascertained by raising it between the operator's eye and the candle, after which it is dried between several folds of very white blotting-paper, and left so until it has to be placed in the frame, behind a sheet of very clean and dry paper, and between two glasses, as in the moist operation previously described.

The exposure to which we afterwards proceed next day, varies according to the light and the power of the object-glasses, from one to five minutes.

On returning to work, the part of the paper which has been presented to the light is deposited in a saturated layer of gallic acid, taking care to secure the other side from any trace of gallic acid which would stain it. The image is gradually formed, and finally acquires as powerful tones as can be desired; it is then washed in a great quantity of water, then parts into a solution composed of 1 part of bromide of potassium and 20 parts of water, in order to dissolve the unreduced salts of silver, then again washed to remove all traces of this bromide, whose action, by continuing, would destroy the image, and finally dried between folds of blotting-paper.

Preparation of the Dry Albuminous Paper.—The paper prepared by albumen has analogous properties to that in the preparation of which serum is used, but in an inferior degree; like it, it remains good for an almost indefinite period after preparation with the iodide, but, after having been submitted to the aceto-nitrate of silver, it can be scarcely kept beyond next day. The proofs given by the preparation we are about to describe are admirable; not so fine as those on glass, they have more charms, because the contrasts are less decided, and they possess more harmony and softness. We think that it *is* a real acquisition for those who seek the effects of art in the results of photography.

White of egg, to which have been added thirty drops of a saturated solution of iodide of potassium and two drops of a saturated solution of bromide of potassium to each white of egg, is beaten up to a snow. It is left to repose until the snow returns to albumen in the liquid state, and then filtered through silk or clear muslin, the albumen being collected in a large and quite flat vessel. The paper to be prepared is then deposited on the layer and left on it for a few minutes. When it is covered with albumen, it is raised by one of its corners, and allowed to drain and dry by suspending it by one or two corners from a line.

The preparation with the aceto-nitrate is, in every respect, the same as that described for the paper prepared with serum; care must be taken to dry it between two folds of blotting-paper only when the paper has acquired complete transparency. It is put into the frame for exposure in the same manner, the appearance of the image and the rest of the operation is the same; but the exposure requires a longer time, generally four or five minutes.

Preparation of the Positive Albumen Paper.—The positive paper prepared with albumen gives somewhat less brillant proofs, but of a richer tone, and of a more agreeable finish and transparency; it is prepared in the following manner:—To the whites of eggs is added 25 per cent. (by weight) of water saturated with chloride of sodium. The white of eggs is beaten into a snow, and filtered as in the preceding preparation, only in this case the paper is left on the albumen for only half a minute. It is then hung up to dry, which is accomplished in six or eight minutes; it is afterwards deposited in a vessel containing 25 parts of nitrate of silver and 100 parts of distilled water. The paper is left in the bath at least six minutes, and afterwards dried flat.

CALEDONIAN CANAL.

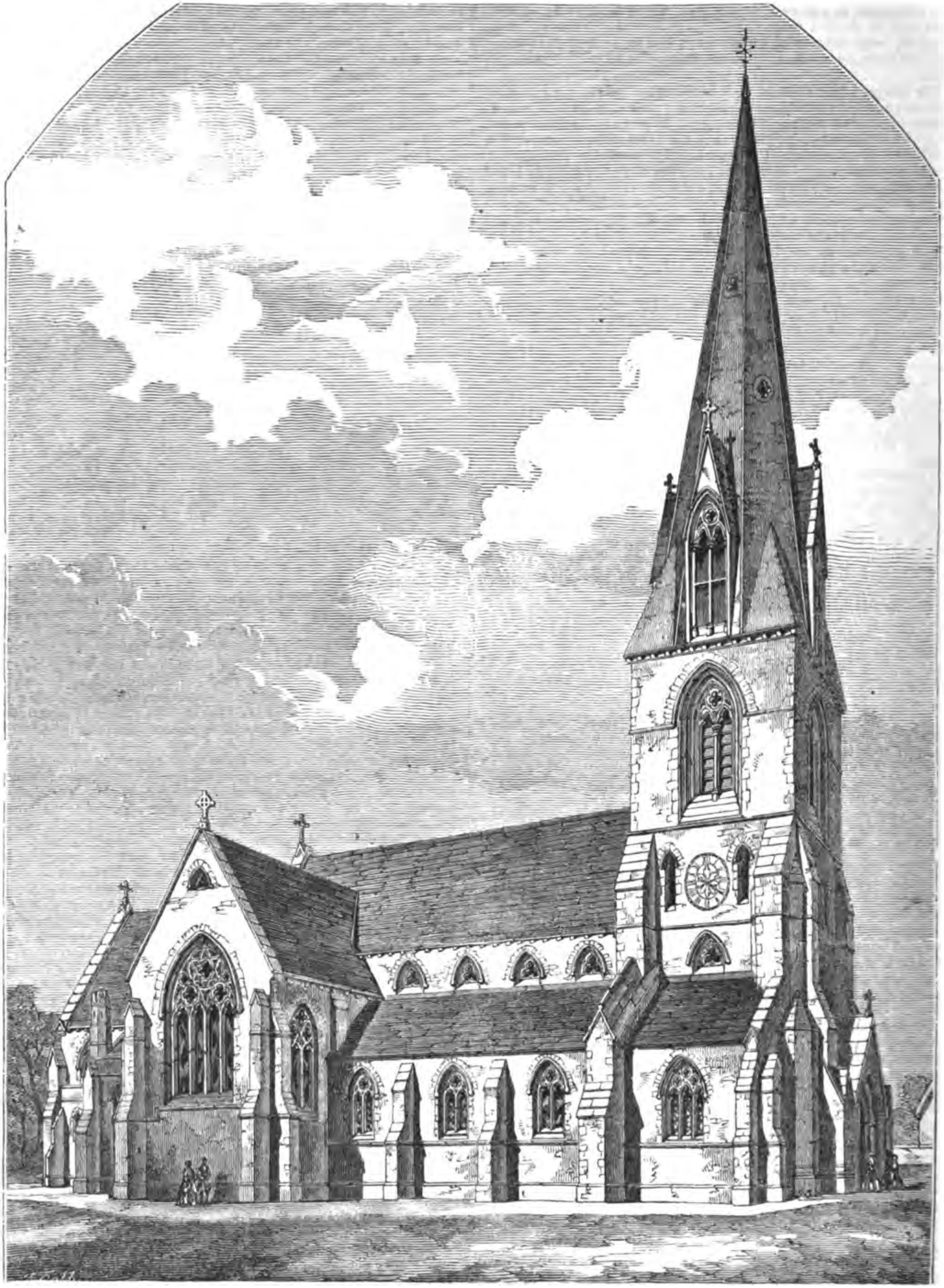
The annual report of the Commissioners for making and maintaining the Caledonian Canal has just been printed. The report gives an outline of the operations of the Committee till the 1st of May last.

The repair of those portions of the canal works which suffered from the unprecedented floods of January 1849, has been entirely completed in the past year, without interruption to the traffic. It has also been thought advisable to secure the works against the effects of a similar visitation, should such unhappily recur; and with this view, under the advice of Mr. Walker, the south-east bank of the canal above Doch-Garrock Lock has been strengthened, and raised about two feet and a-half above the highest level of the inundation. The gates of the lock itself are of such a height as to require no addition. An increase of two feet in height has been given to the canal bank of the reach above Aberchalder, and of three feet to the banks above and adjoining Laggan Locks; but in both these instances a corresponding addition to the height of the masonry and lock-gates is required, which has not yet been effected from the apprehension of temporarily obstructing the navigation.

Various additional accommodation and facilities for traffic have been supplied along the line of the canal, which leave little now to be desired for the convenience either of passengers or of trade. At Clachnaharry, the timber jetty at the Sea Lock has been extended so as to obviate the risk of vessels grounding on the sloping embankment: a similar jetty has been constructed at Corpach. At Muirtown, the road of approach to the steamboat wharf has been widened. The steamboat stations at each end of the canal have been properly lighted: the roadway along the Dochfour embankment has been completed and fenced. The only further accommodations to which the Commissioners conceive that their means might legitimately be devoted are, a small landing pier or slip at Fort Augustus for vessels engaged in the local trade, and an embankment track-path on the north-west side of the canal between the Old and the New Gairlochy Locks, which are at present connected only on the opposite side. The erection of landing piers at the different points where the steam-boots touch on the Lakes, would be of much convenience, and the accommodation of a graving dock or patent slip for the repair of large vessels at the eastern end of the canal is highly to be desired, but these are rather subjects for individual enterprise.

The sum of 10,000*l.*, granted by parliament for the repair of the damages to the canal works, occasioned by the floods of January 1849, was issued in August last, and there is no reason to doubt that the anticipations of its sufficiency for the entire restoration of the works, and also for the completion of the several precautionary measures above alluded to, will be verified.

With regard to the Crinan Canal, the report states that the condition of this navigation has been much improved by various important repairs. The upper gates of the summit lock at Cairnbaan (No. 8), and also of the second lock at Crinan (No. 14), have been renewed. By means of a small dredging apparatus fitted to the canal barge, an additional depth of near two feet has been gained in the entrance to the canal through the harbour of Ardrishaig, greatly diminishing the period of detention (sometimes five or six hours), long complained of by masters of vessels, especially of steamers, which drawing ordinarily about seven feet water, were previously unable to enter or depart from the canal after half-ebb on the falling tide, or before half-flood on the rising tide. The dredging apparatus has also been usefully applied in restoring the canal to its full depth at spots where, as at Dunardry, the deposit from burns discharging into it had greatly encumbered the bottom. The reduction of dues upon the navigation, which was announced in the last report, has not diminished the revenue, although the tariff of charges on the principal articles conveyed was reduced by nearly one-third. The revised tariff was in force for the last nine months only of the year 1849, during which time the increased resort of sailing vessels produced 1135*l.*, as compared with 1113*l.* in 1848. Out of 729 vessels entering or clearing from the Clyde from or to northern ports, and capable of passing the canal, only 353 (or 48½ per cent.) took the passage round the Mull of Cantyre, whereas in the corresponding period of 1848, that course was adopted by rather more than 62 per cent. of the vessels under similar circumstances. In the months of January, February, and March 1850, this proportion was reduced to about 21 per cent., but it increases as the approach of summer diminishes the danger of the more exposed and circuitous course. The dues on steamboats were not reduced at the time of the revision of the general tariff; but by an alteration sanctioned in the course of the month of May in the present year, the commissioners have authorised a reduction of the tonnage rates leviable upon steamboats from 9*d.* to 6*d.* per ton, and also of the harbour rates at Ardrishaig and Crinan from 1*d.* to ½*d.* per ton.



NEW PARISH CHURCH, SWINDON, WILTS.——George Gilbert Scott, Architect.

NEW PARISH CHURCH, SWINDON, WILTS.

The annexed engraving is a view of a new church that is now in course of building, under the superintendence of Mr. Scott. The situation is an elevated spot near the town of Swindon, Wilts. The building is of the Decorated period, and constructed with stone, the dressings being of Bath stone worked. The total length of the church is 145 feet; breadth 55 feet. Transepts 80 feet long, and 23 feet wide; height from floor of nave to top of ridge of roof, 50 feet. Tower, 24 feet square; and height, including spire, 145 feet. The church will contain 926 sittings, and the cost between 6000*l.* and 7000*l.*, raised by voluntary subscriptions, and a grant from the Incorporated Church Building Society. The contractor is Mr. George Myers, of the Westminster-road.

BRITISH ASSOCIATION.

Selections from Papers read at the Meeting held at Edinburgh, August, 1850.

ANCIENT GREECE.

Notices of some additions made to our knowledge of the Ancient Greeks by recent discoveries in Greece. By Professor Rangabe, of Athens.

There exists one subject—one in particular—by which I may venture to say that Greece must excite to the highest the interest of the learned—namely, that of her ancient monuments, which can never cease to be an object of universal study and admiration; and I may, perhaps, all the more hope to be heard with indulgence, while I attempt to give a short account of the principal facts with which the science of archæology has been enriched by the discoveries made in Greece since her affranchisement, that it is to the learned investigations of British antiquarians in particular that is due most of the knowledge we already possess of the Hellenic monuments. Like those towns of Italy which reappear in their ancient splendour when their covering of lava is removed, Greece, as soon as she had shaken off the slavery of so many centuries, offered to the admiration of the world the innumerable treasures of her antique beauty; and her monuments, after having seen so many barbarian conquerors pass over their ruins, and after having been so often exposed to destruction, and after—may not I, whose days are passed among the mutilated remains of the Parthenon, be permitted to say so?—the severe damage inflicted on them by the too fervid zeal of a distinguished amateur, became once more the objects of a renewed worship, as soon as her freedom had rendered Greece accessible to all, and an enlightened government, aided in its efforts by an archæological society, had restored them to light.

Among these monuments there are many which cannot fail to excite interest in the most indolent imagination. They are those which bring us back to times which we are accustomed to see through the prism of poetry, and which disclose to us at a period antecedent to history, a powerful civilisation—which we find indeed in the songs of Homer, but which we are rather disposed to look upon as an effort of the sublime imagination of that great genius of heroic time.

Before the emancipation of Greece, the traveller, gazing in wonder on the gigantic walls of Tyrinth and Mycenæ, was inclined to ask if their construction was not rightly attributed by fable to superhuman workmen; and, in order to complete the first page of Hellenic ethnography, illustrated by existing monuments, he was obliged to have recourse to the Tyrrhenian towns of Italy.

But the country of Agamemnon, now more easily traversed, and more carefully explored, is found to be covered with a great number of edifices belonging to the time of the *Anaktes*. Captain Soitoux—one of the most indefatigable members of the French commission, which has rendered so great a service to science by its excellent map of Greece—saw in the wild ravines of Acarnania more than thirty foundations of towns, of Cyclopean construction. In Arcadia—the dwelling place of the Pelasgians, who pretended to have seen the creation of the moon, and who at least preceded the Hellenic race—polygonical walls are discovered every day; and in a valley unknown to travellers between the lake Stymphalus and the Mount Trachys of Orchomenus, I had myself the happiness, two years ago, of discovering at the very spot where Pausanias (viii. 23) places it, the town of Halia, long sought for, and not as yet perceived by any of my predecessors. This ruin presents one of the most imposing examples of Pelasgic architecture, and at least two-thirds of it are in a state of rare preservation. Its form is that of a triangle, whose base lies along the foot of the mountain, and whose two sides rise up on its flank. The latter only are standing, and they attain often a height of 16 ft., and contain 37 square towers. A parallelogram traced on the summit of the triangle, forms the acropolis of the fortress, whose walls are composed of gigantic polygonical blocks, and the lintel of whose doors consists of two inclined stones, which mutually support each other.

But in Argolis, the very seat of the power of the Atrides, the discoveries have not been few. At the same time with Halia, I saw in a little valley, separated from the Argolic plain by a rising ground, and quite close to Mycenæ, a square edifice till then unknown, of the finest polygonical style, each side being 38 feet in length, and rising in perfect preservation to the height of 10 feet, where its coping still exists. The interior was divided into three compartments, but the separations are almost entirely destroyed. This monument is one of the most interesting that has yet been discovered, as it discloses to us a particular branch of Homeric architecture. It is difficult to believe that at so short a distance from Mycenæ, an edifice belonging to the class of those which excited so highly the admiration of the ancients, should remain unnoticed by them; I am therefore tempted to suppose that this is no other than the Tower of Polygnotus, as it was called, where Aratus, on his way from Argos to Phlius, had a meeting with his conspirators (Plut. Vit. Arat. 6 and 7).

The famous Temple of Juno at Argos, the scene of the pious exploit of Cleobis and Bion, was discovered after the deliverance of Greece. Under the ruins of a new temple, which had been built about the 90th Olympiad, and magnificently decorated by Polycletus, is to be seen the gigantic foundation of the ancient sanctuary, which was burned about that same period by the negligence of the priestess Chrysis, and is now the only religious ruin, authentically proved, belonging to an epoch anterior to historical times.

I was present at the excavations made at Tyrinth by the illustrious German antiquarian, Thiersch, and I witnessed the highly interesting result which he obtained. On the western side of the hill of the Cyclops, he discovered a range of bases of columns; and this fact, combined with the column already known in the Treasury of the Atrides, and that of the basso-relievo of the lions at Mycenæ, tend to modify the ideas held until now on Pelasgic architecture, and to prove that the principle of the columns—of a primitive form, undoubtedly, but containing the germ of the diverse forms developed later by the Dorians and Ionians—was, if not an indispensable part, at least an ornament frequently employed in the buildings of Homeric times. Another discovery of the highest importance to the architecture and ethnological history of that remote period has just been made in the south of Eubœa. Walpole had already seen and described (Travels vol. i.) on the summit of Mount Ocha, an edifice of a peculiar form and of an archaic style. Its walls are composed of very large parallelogramical blocks, of unequal dimensions; and its roof consists of several layers of stones, which advance on each side towards the centre, jutting out considerably the one beyond the other, instead of forming a smooth surface as in the Treasury at Mycenæ. But from this specimen of architecture, curious as it was from its differing from the usual forms of ancient art, no conclusion could be drawn to further our knowledge of that art, because it only furnished one isolated example. But at Styra, the town famous for its quarries, situated at the northern foot of the same mountain, the discovery was made a few years ago, of three buildings of the same nature, one of which is peculiar for its roof being circular. On another peak of Mount Ocha, I myself visited, only last summer, several edifices, the evident remains of a very ancient town, suspended on the brink of an abyss equally inaccessible by sea or by land, and known only to the shepherds of those wild regions, who give it the name of *Archampolis*, or ancient town. These buildings are constructed on the same architectural principles; and I have heard another position described not far from the Cavo d'Oro, as the Venetians called the Caphareus, where more such ruins exist. It is very remarkable that all these constructions, which, though belonging to the general system of Pelasgic architecture, differ sufficiently from it to contribute a class apart, are all found grouped in so considerable a number on one point of Greece; and this circumstance leads one to presume, that this style belongs properly to some tribe, which, having its principal seat in the deep valleys of the Ocha, emanated, like all those which occupied in heroic times the soil of Greece, from the common stock of the Pelasgians, but which had a character sufficiently distinct from the other branches, to have developed the art of building in a particular sense. And in this race, in my opinion, we may recognise the *Dryopes*, who, in the most remote times, expelled from their ancient seats in Thessaly, came to occupy the southern part of Eubœa, just the spot where these constructions of so ancient a style, and so distinct from all other examples offered to us by history, have been discovered.

But the discoveries made in Greece since her emancipation have not less served to rectify and to extend the notions already possessed on *Classical* Architecture. The Propylea having been disencumbered from the modern fortifications which concealed them from view, and having now re-appeared in all their ancient harmony, it is easily recognised that their magnificence corresponded fully with that of the immortal monuments to which they gave access, and that their superb flight of steps occupied the whole width of the entrance to the Acropolis, descended probably to the Agora, and was ornamented on either side by terraces supporting statues and temples. One of the latter, the Temple of Victory, without wings, the finest jewel of the Acropolis' crown of monuments—which had disappeared between 1676, when Sphon and Wheeler travelled in Greece, and 1751, when Stuart visited it—now discovered again under a Turkish bastion, and restored, offers to study one of the purest and most perfect examples of the tetrastylos amphiprostylos of the Ionic order which exists in the world. The mouldings of its entablature, as well as those of the Propylea and of the Parthenon, bear evident traces of painted ornaments, and put it beyond all doubt that the ornamental parts of the temples were painted in Greece, like those of Sicily, in the time of Pericles, as well as at more ancient periods, when they were often replaced by terra-cotta. In the Pinacothek, which contained the famous pictures of Protogenes, the walls which the French or Catalanian dukes had constructed to convert this part of the Propylea into their Chancery having been destroyed, the original partitions have been brought to light; and I think that the examination of these and of the walls of the Temple of Theseus, may give the solution of the question which had been the subject of so much controversy—namely, whether the ancients painted exclusively on the walls or on panels of wood, by proving that the Pinacothek was covered with panels, or, rather, moveable pictures; whereas the paintings in the Temple of Theseus were executed on stucco fixed to the wall itself. And I may here mention that one of the greatest connoisseurs of the paintings of the ancients—M. Raoul-Rochette, of the Institute of France, is now occupied in putting together all the recent information obtained on this subject, with the intention of working it into a special treatise.

The Parthenon, in spite of the exact and conscientious work of Cockerell, when delivered of the barbaric ruins which insulted its grandeur, had still secrets to disclose; and it is well known that attentive observations have taught the astonished architects of modern times, that of all those lines whose magnificent harmony is the source of the inimitable beauty of this edifice, there is not one which is a straight line; that with a depth of science which would put to fault the calculations of the profoundest mathematician, the architect, imitating nature, who avoids a straight line in her organic productions, had composed a system of curves beyond the skill of modern art to combine or reproduce.

The Erectheum, that enigma of architecture, can also be better understood since it has been raised from its ruins; and in my opinion it is now evident that this temple was double, in spite of its having four names, and that the singular distribution of the house consecrated to Erectheus which it replaced had been adopted in its construction. The new notions obtained on this temple have been most ably discussed in the Annals of the Academy of Munich, by the most learned philologian of Germany, M. Thiersch, who is now preparing a second work on the same subject.

To the study of Sculpture the results have not been less important. Each fragment fallen from the chisel of a great master, and now withdrawn from the dust, is an inestimable treasure. The excavations made around the Parthenon have augmented our glyptic riches with twenty-one pieces of the frieze, one metope, and six large fragments of statues belonging to the front of the temple, all master-pieces, which serve, in a slight degree, to console the Greeks for the painful losses made at a time when it was not in their power to prevent them. I may say as much for the blocks of the frieze of the Temple of Victory, which are the completion of those carried away by Lord Elgin. The discovery of the frieze of the Erechtheum is not a less precious one: its existence even was unknown, when twenty-one small statues of equal dimensions were found in the rubbish. They are of white marble, and having the back part of each quite flat, were evidently applied to and detached themselves from a back-ground of Eleusis stone. The execution is of the purest style; and they allude, I think, to the procession of the Pandrosus, to the birth of Erichthonius, and to the loves of Mars and Mercury with Agraulia and Herse.

I shall not enter into a detailed enumeration of all the invaluable pieces of sculpture which have been gathered into the Museum of Greece. But there are several which have enriched antiquarian knowledge with entirely new facts. It is thus that a very remarkable low relief, found in a cemetery on the east coast of Attica, and representing a warrior larger than life, serves as a precious stepping-stone for the history of art among the ancients, by affording a very important specimen of the archaic school of Athens, and particularly of the manner of *Aristocles*, whose name is inscribed on it, and who, according to my idea, flourished about the 66th Olympiad. Having come from Sikyon, where his grandfather had established himself after leaving Crete, this artist may be considered as representing the connection between the different schools of archaic art. This fine low-relief also teaches us, that at the most remote period the same habit existed, which continued in later times, of painting works of sculpture, or at least the ornamental parts and accessaries of them.

Among the inscriptions recently discovered, and which serve to extend our archæological information, I shall only mention the most important to the history of art, such as those which give us new details on the epoch and the works of divers sculptors. It is thus by one of them we learn that *Eudaeos*, thought to be the pupil and relation of Dedalus, was, in fact, only a *Dedalides*, an artist of the archaic school, and not more ancient than Aristocles. We learn from another, the existence of a sculptor of the same epoch, named *Nesiotes*; and from a third, that it was *Strongylion* who executed the famous *Durian* horse on the Acropolis.

Among those which throw a stronger light on the public life of the ancients, I shall mention one which, consisting of more than 120 fragments, contains the list of the allied towns which paid tribute to Athens. The knowledge of these enriches ancient geography with a number of names unknown until now, and completing the political history of Athens, gives a more exact idea of its greatness. The tribute-money seems to be calculated for a month, and the list only to contain the tenth part, or the share belonging to the temple. As far as the mutilated state of these fragments permits one to judge, that share seemed to have amounted to nearly five talents and a-half a month. Several other inscriptions complete the lists already known of the treasures contained in the Parthenon, and the result to be obtained from them is, that in the days of the splendour of Athens, the temple contained objects in silver and gold, weighing together about 17 talents of silver. From another of these inscriptions, we can calculate the rate of interest paid to the Parthenon when the funds of the temple were lent to the town. I estimate this rate at 10 drachmas per 50 talents every day, or 1¼ per cent. for a year. Other inscriptions not less precious, which have served as a basis to the learned work of M. Bœckh, throw a great and new light on the most powerful element of Athenian greatness, the organisation and importance of their navy. The expense of the first expedition to Corkyra (Corfu), which opened the Peloponnesian war, forms the subject of one of them; and I pass over in silence a great number of monuments illustrative of more than one important point of history, such as the political calendar of the Athenians; their relations with foreign princes and nations; the detailed organisation of the Amphiktyonic league; the position of private slaves, and of the *hierodules*, or servants of the temple; questions of topography and others relating to the public games.

I have only mentioned the discoveries the most rich in results, and the principal contributions which Greece has brought to the science of antiquity since her emancipation. And if it is true that my account is still far beneath the reality, and that a very abundant source of archæological knowledge, obstructed by the ruins under which centuries and barbarisms had buried it, has now been re-opened in Greece by the power of liberty, and by the enlightened efforts of a regular government, I hope I shall be allowed by the lovers of antiquity to advance, that the emancipation of Greece has not been a regretable event, as some seem to have wished to make it appear, and that Greece has by this return alone repaid the greater part of the sacrifices made in her favour.

INCRUSTATION IN STEAM BOILERS.

On the Incrustation which forms in the Boilers of Steam-Engines, in a letter addressed to Dr. G. Wilson, F.R.S.E. By Dr. J. Davy.

On entering on this inquiry, which I did after my return from the West Indies in December, 1848, and after communicating a short paper to the Royal Society "On Carbonate of Lime in Sea-water," it appeared to me desirable to collect as many specimens as possible of incrustation from the boilers of steam vessels, now so widely employed in home and distant navigation. By application to companies and to friends in our sea ports, as Dundee, Hull, Southampton, Hayle, Liverpool, Whitehaven, I have succeeded in procuring specimens of incrustation formed by deposition in voyages from port to port, in the British and Irish Channels, and the North Sea, between Southampton and Gibraltar, in the Mediterranean and the Black Sea, and in the Atlantic Ocean, between Liverpool and North America, and between Southampton and the West Indies. I am promised specimens from the Red Sea and the Indian Ocean—but these I have not yet received.

The character and composition of the incrustation, whether formed from deposition from water of narrow seas or of the ocean, I have found very similar—with few exceptions, crystalline in structure, and, without any exception, composed chiefly of sulphate of lime; so much so, indeed, that unless chemically viewed, the other ingredients may be held to be of little moment, rarely amounting to 5 per cent. of the whole. From two specimens of incrustation from the boilers of steamers crossing the Atlantic, one of which you sent me, in which you had detected a notable portion of fluorine, judging from its etching effect on glass,—I also procured it, it was in combination with silica; and procured it also so combined from two obtained from steamers navigating our own seas, one between Dundee and London, the other between Whitehaven and Liverpool. Of this I had proof, by covering with a portion of glass or platina foil a leaden vessel charged with about 200 grains of the incrustation mixed with sulphuric acid, and by keeping the glass cool by evaporation of water from its surface, and by supplying moisture for the condensation of the silicated gas by a wet band round the mouth of the vessel. After about twenty-four hours under this process, a slight but distinct deposition was found to have taken place, corresponding to the margin of the vessel—a deposition such as that produced by silicated fluoric acid gas under the same circumstances. Thus it was not dissipated by heat nor dissolved by water, and yet admitted of removal by abrasion, either entirely or in great part; the former in the instance of the platina foil, the latter in that of the glass. Besides the ingredients above-mentioned, I may add that, in many instances, oxide of iron, the black magnetic oxide, was found to form a part of this incrusting deposit, collected in one or more thin layers, and further, that in some, especially of steamers navigating the narrower and least clear part of the British Channel, the depositions presented a brownish discolouration produced by the admixture of a small quantity of muddy sediment. Incrustations so discoloured, I may remark, are reported to be most difficult to detach.

I have said that the incrustations, with few exceptions, were similar in their structure, and that that was crystalline; it was not unlike the fibrous variety of gypsum of the mineralogists. The specimens received, as might have been expected, varied very much in thickness—viz., from one line and less to half an inch. I have endeavoured, by a set of queries which I had distributed, to obtain information respecting the exact time in which the incrustations were formed, and under what circumstances; but with partial success only, owing to a want of exact observation. In one instance, that of the North American mail-ship *Europa*, which arrived at Liverpool on the 15th of November, at 4 p.m., having left Boston on the 7th of the same month at 9 a.m., an incrustation was found in her boiler of about one-fiftieth of an inch in thickness; and it is stated that an incrustation of about the same thickness was found on her outward voyage. This example may aid in giving some idea of the degree of rapidity with which the incrustation is produced, at least in the Atlantic, with the precaution of "blowing-off" every three hours, and with the "brine pumps" kept in constant work. In other seas, especially contiguous to shores, and more especially of shores formed by volcanic eruptions, it is probable, *cœteris paribus*, the rate of the deposition of the incrusting sulphate of lime will be more rapid. The results of the trials of several portions of sea water taken up on the voyage from the West Indies to England noticed in the paper of mine already referred to, are in favour of this conclusion.

To endeavour to prevent the deposition of the incrusting matter or to mitigate the evil, various methods, it would appear, have been had recourse to—some of a chemical kind, as the addition of muriate of ammonia and sulphate of ammonia to the water in the boiler—without success, as might be expected; others, of a mechanical kind, with partial success—as the introduction of a certain quantity of saw-dust in the boiler, or the application of tallow, or of a mixture of tallow and plumbago to its inside, to prevent close adhesion, and the more easy separation of the incrusting matter either by percussion, using a chisel-like hammer, or by contraction and unequal expansion, by means of flame kindled with oakum, after emptying the boiler and drying it. Of all the methods hitherto used, that of "blowing-off"—that is, the discharging by an inferior stop-cock a certain quantity of the concentrated water of the boiler by the pressure of steam, after the admission above of an equivalent quantity of sea water of ordinary density, appears to be, from the reports made, the most easy in practice, the least unsuccessful, and the most to be relied on. But, as in the instance given of the North American steamer, it can be viewed only as a palliation.

Considering the composition of the incrusting matter and the properties of its principal ingredient—the sulphate of lime, a compound soluble in water and in sea water, and deposited only when the water containing it is concentrated to a certain degree, there appears to be no difficulty theoretically in naming a preventive. The certain preventive would be the substitution of distilled or rain water in the boiler for sea water. Of this we have proof in the efficacy of Hall's condenser, which returns the water used as steam, condensed, after having been so used; but, unfortunately for its practical success, the apparatus is described as being too complicated and expensive for common adoption. Further proof is afforded in the fact, that the boilers of steamers navigating lakes and rivers in the waters of which there is little or no sulphate of lime, month after month in continued use, remain free from incrustation. This I am assured is the case with the steamers that have been plying several summers successively on the lake of Windermere. And it may be inferred, that in sea-going steamers in which sea water is used in the boiler—or, indeed, any water containing sulphate of lime, the prevention of deposition may be effected with no less certainty by keeping the water at that degree of dilution at which the sulphate of lime is not separated from the water in which dissolved.

From the few trials I have made, I may remark, that sulphate of lime appears to be hardly less soluble, if at all less, in water saturated with common salt than in perfectly fresh water. This seems to be a fortunate circumstance in relation to the inquiry as to the means of prevention, and likely to simplify the problem. If these principles be sound, their application under different circumstances, with knowledge and judgment on the part of the directing engineer, will probably not be difficult. His great object will be in sea-going steamers to economise the escape of water in the form of steam, and thereby also economise heat and fuel; also, when fresh water is available, to use it as much as possible; and further, to avoid using sea water as much as possible near coasts and in parts of seas where sulphate of lime is most abundant. From the incrustation on the boilers of sea-going steamers, the attention can hardly fail to be directed to that which often forms, to their no small detriment, in the boilers of locomotive-railway engines, and of engines employed in mines and in the multifarious works to which steam power is now applied. These incrustations will of necessity be very variable, both in quantity and quality, according to the kind of ingredients held in solution in the water used for generating the steam.

Hitherto I have examined two specimens only of incrustations taken from the boilers of locomotive engines, and a single one only from the boiler of a steam-engine employed on a mine—a mine in the west of Cornwall. The latter was fibrous, about half an inch thick, and consisted chiefly of sulphate of lime, with a little silica and peroxide of iron, and a trace of fluorine. The former were from one-tenth of an inch in thickness to one inch. They were laminated, of a grey colour, and had much the appearance of volcanic tufa; they consisted principally of carbonate and sulphate of lime with a little magnesia, protoxide of iron, silica, and carbonaceous matter—the last two, the silica and carbonaceous matter, probably chiefly derived from the smoke of the engine and the dust in the air. From the engineer's report it would appear that the thinnest—the incrustation of about one-tenth of an inch—had formed in about a week, during which time the locomotive had run about 436 miles, and consumed about 10,900 gallons of water.

IRON FORGING.

Improvements in Forging Iron. By JAMES NASMYTH.

BEFORE proceeding to describe the nature of the improvements in question, Mr. Nasmyth made some remarks on the value and importance of any improvement which tended to increase the certainty of the production of sound and perfectly solid forgings of wrought-iron, more especially those massive forgings required for such purposes as paddle-shafts, marine engines, crank and plain axles for locomotive engines, anchors, and such like, on the soundness of which both life and property to a vast amount may depend.

Mr. Nasmyth instanced cases in which paddle-shafts of marine engines had given way, although in the first instance they had all the *outward* aspect of the most perfect soundness, but which on fracture exhibited the existence of original defect, in being little else internally than a mass or bundle of loose bars of iron, which had never been in a sound welded union, but had only been held together by the exterior, where alone the welding had been so far perfect.

Mr. Nasmyth exhibited a diagram of which fig. 1 is a copy, in order to illustrate the action induced on the centre portion of a cylindrical forging, when produced under the action of a flat-faced hammer and anvil.

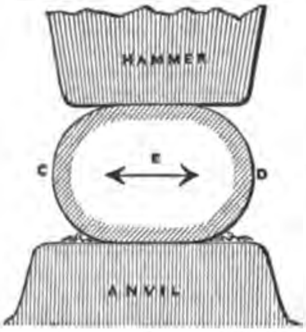


Fig. 1.

It will be seen at once that the action induced on the centre portion of the metal of a shaft, or such like cylindrical form, by the successive blows of a flat-faced hammer and anvil, as A and B is to cause the work to spread out or extend in the direction E D, E C (as represented by the double pointed arrow on the figure); and as the flattened-out form has to be attempted to be corrected by turning the shaft round and round on the anvil, so that each successive blow may be made to correct the spreading out caused by the previous blow. The result of this action is a fretting or mincing of the centre part of the metal of the shaft, resulting in a separation of the metal throughout the entire centre portion of the shaft, somewhat after the manner indicated in fig. 2, frequently to such an extent as to permit the passage of air or water from end to end of shafts forged in this manner.

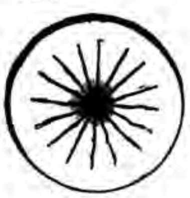


Fig. 2.

The effect of this kind of unsoundness is that it is certain, sooner or later, to work out towards the exterior, and in all probability result in "a break down" more or less disastrous in its consequences.

Mr. Nasmyth then proceeded to describe his improved form of anvil-face, by the employment of which all such defects as detailed above are avoided. Such has been the perfect success and excellent results which have attended the use of his improved anvil-face, that its adoption has become almost universal; and the production of absolutely sound solid wrought-iron shafts, of whatsoever magnitude, rendered equally easy as certain.

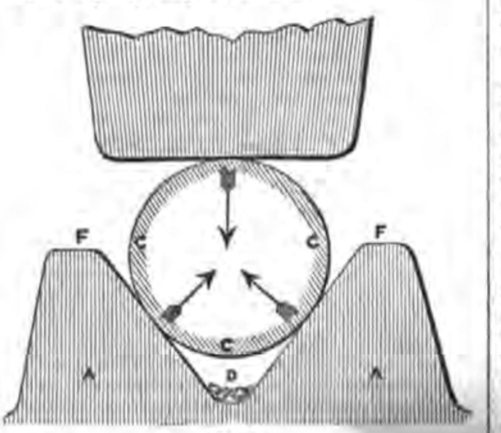


Fig. 3.

A, (fig. 3) represents the form of Mr. Nasmyth's improved anvil-face, which he terms a V-anvil, between the jaws of which the work to be hammered is placed as indicated by a cylindrical shaft, seen in section marked c c o.

A glance at the above figure will, no doubt, render its action evident, namely, that the action of each blow of the hammer on the work c c c, instead of causing, as in the case of fig. 1, a diverging action on the centre portion of the work, occasions, on the contrary, a converging action, as represented by the three arrows; and instead of having the centre portion of the metal of the shaft rendered less compact and solid by the action of the blows of the hammer, we have quite the contrary effect produced; besides which, owing to the wedge-like form and action of this V-anvil face, the compressing effect of the blows are most importantly enhanced, and the ease and rapidity with which such cylindrical-formed work as shafts and the like can be produced under or by such means is most remarkable; so much so as to enable the forgemen to hammer out *at one heat*, by means of this V-anvil, as much as would require three heats on the common flat-face anvil. Add to which the vast convenience which the fork-like form of the V anvil yields in keeping the work at all times right under the centre of the hammer, as it is turned round and round to receive the successive blows, which in the case of work of the largest class is a matter of no small trouble; another advantage consists in the free passage or exit which is at all times preserved for the escape of the scales and impurities which fall from the hot iron during the process of hammering, which scales fall down towards the apex of the V at D, and trickle away, thus removing the cause of blemish and roughness which is caused by such scales collecting on the face of the flat anvil, and get beat into the surface of the forging.

It will be seen on inspecting fig. 3, that one such V-anvil face as there represented, will accomodate a vast range of diameters of work—namely, all variety of diameters, such as will neither absolutely rest on the bottom of the apex at D, or on the corners F F.

Mr. Nasmyth has taken every means, by the most free communication, to promulgate among those interested the advantages of this V-anvil, and has been rewarded by seeing its use become almost universal.

Mr. N. stated that an angle of 80° was found by him to be most generally suitable for the inclination of the sides of the V, and also that the edges should be well rounded off, and the surface of the V sides curved in the direction of the *axis* of the work, to the extent of $\frac{1}{8}$th of an inch in 12 inches, so as to be "proved" in the centre, and so facilitate the extension (axis ways) of the work. The vast simplicity, as well as the important results, which are yielded by the employment of this V-anvil face, has, in no small degree, contributed to its almost universal adoption. Its employment renders the production of perfect sound work as easy as certain.

Mr. Nasmyth next proceeded to describe the second part of his improvements in forging iron, which consist as in the first case, of means equally certain and simple in producing sound boiler plates. Mr. Nasmyth prefaced his description of his improvements on this truly important subject by detailing the nature of the most frequent *cause* of unsoundness in iron forgings generally, and in boiler plates in particular, namely, the imperfect expulsion of the molten oxyd of iron, or "scoria," or "cinder," as it is termed, which in every case of welding hot iron covers and clings to the surface of the metal; and if left interposing between the welded surfaces, is certain to occasion a defect greater or less according to the surface of junction it occupies. The frequency of this interposing scoria as *the true cause* of unsound forged work was forcibly alluded to by Mr. Nasmyth, and shown to be the most fertile source and cause of the failure of wrought-iron work, resulting as such too frequently does, in the most sad and disastrous accidents, such as the failure of the links of chains and anchors, and in the costly and often distressing results arising from defective, *i. e.* blistered boiler plates.

In respect to the links of chains, Mr. Nasmyth mentioned as the result of an extensive series of experiments on the strength of chain cables, on which, as member of "the committee on metals," he was employed by the Admiralty; out of every ten cases of fracture, eight were occasioned by defective welding, as evinced by the appearance of the surfaces, which present to a practical eye appearances not to be mistaken, owing to the very peculiar aspect of the surface of the *apparently* welded metal, between which surfaces the oxyd or scoria had not been duly expressed.

Mr. Nasmyth further described the condition absolutely requisite to perfect welding, namely, not merely that the surfaces we desire to weld should be really "welding hot," but also that when brought into contact, no particle of the scoria, which inevitably clings to the metal while welding hot, should be permitted to remain interposing between such surfaces as we desire to weld. If such material is left interposing, we are certain to have defect and unsoundness to a greater or less extent as the result.

In order the more clearly to detail his improvements on this important subject, Mr. Nasmyth exhibited a coloured drawing representing the usual form and arrangement of "a pile" of "slabs" such as are employed in forming, when welded together, a mass of iron from which boiler plates or bars of iron are rolled. Fig. 4 represents such "a pile" of "slabs," which having been, as is generally the case, produced under the action of a forge hammer and anvil, having flat, or as is generally the case, slightly convex surfaces, causes the slabs so produced to have certain hollow parts, or slightly concave portions of their surfaces, so that when piled one upon the other, as in fig. 4, the risk of having hollow spaces between is almost certain. The hollow spaces are represented in the figure by the dark irregular lines between the slabs.

Referring to fig. 4, A, B, C, D, represent a pile of four slabs laid on the anvil welding hot; owing to the *concave* irregularities of the surfaces, the parts most certain to come into contact first are generally the exterior edges of the slabs. The effect of the blows of the hammer is first to weld the parts in natural contact; and by continuance of the blows, the interposing scoria or "cinder" is expressed, in a degree more or less perfectly, according to the energy of the blows and the deepness of the convex or hollow patches betwixt the slabs. So long as there exists an exit or passage for this scoria, all is well; but, as generally happens, some portion of this scoria lurks behind after all chance of escape is removed by the welding of the exterior portion of the surfaces of the slabs. The result of this is, that we have to a certainty a defect greater or less in amount, according to the quantity or surface over which the *inclosed* scoria extends: once such scoria is shut up between the surface of the slabs, no amount of after hammering will ever expel it, but on the contrary, will only tend to its extension over a larger surface; and, as before said, so long as a particle of this scoria is left interposing, so have we a degree of unsoundness in proportion.

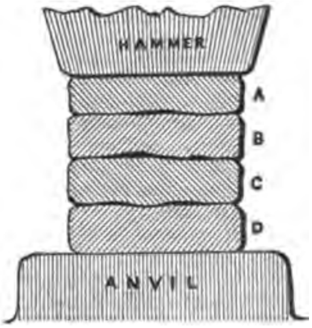


Fig. 4.

Great as this evil is, and common as it is as a fertile cause of defective iron work, and the more especially so in the case of boiler plates, the means of avoiding such source and cause of defect is as simple as the results are important; and it is to be hoped that the free and open communication which Mr. Nasmyth has made of his views on this subject will be answered in the most acceptable way by the general adoption of his improvement or certain means of avoiding the occurrence and existence of all such causes of defective boiler plates, and forged work generally; which improvements consist simply *in so forming the surfaces which we desire to weld together that a free exit may be preserved to the last for the escape of the molten oxyd or scoria until the entire surface of the parts we desire to weld are thoroughly incorporated by the welding property, aided by the action of the hammer or rolls, as the case may be.*

In order to accomplish this most important and desirable object, Mr. Nasmyth forms the surfaces of his slabs *convex* (see fig. 5); by which most simple common-sense-means a perfect free exit to the scoria or interposing impurity is maintained to the last moment, the welding commencing at the centre part of contact W, and extending outwards towards the edges under the action of the successive blows of the hammer, or squeeze of the rolls; but, as before said, an open door is kept for the escape of the scoria until the surfaces unite *from* the centre W *to* the outer edge Z, Z, Z, Z. Here, then, by an arrangement or formation of the surfaces we desire to weld, we have the most certain and simple means of procuring a perfectly solid sound mass of iron which, when beaten, hammered, or rolled down to whatsoever thickness we desire, will retain, to the last, all the qualities of the one sound solid mass we had converted it into by this most simple improvement—namely, giving to the surfaces we desire to weld a convex form and relation to each other.—Mr. Nasmyth concluded his observations on these important subjects by an earnest appeal to the members of the Mechanical Section to diffuse, by all means in their power, the information which, on this as on all such subjects, he shall ever feel the highest pleasure in communicating to the practical men of his profession, and the world in general, who may think fit to accept these results of an active life, which he finds so much real pleasure in freely sharing with them.

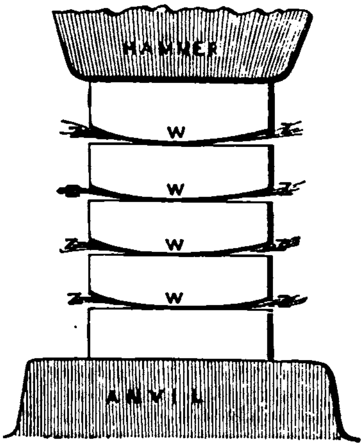


Fig. 5.

POWERS OF MINUTE VISION.

On the Powers of Minute Vision. By Mr. W. Petrie.

Results from experiments for determining the best sort of station-marks, and the errors liable, in observing with optical instruments that measure on the principle of bringing two reflections together. The experiments were performed in bright daylight (but not sunshine), being light of the maximum of advantage for perceiving black against a white ground. The general circumstances of the experiments were arranged rather to determine the facts of common practice, than the theoretic powers of vision.

Mr. Petrie then detailed the various distances at which circular spots, lines, &c., white on black as well as black on white, could be seen, the distances being given in terms of the breadth of the object seen. An arrangement of lines was described, by which an alteration of their position to the extent of only *one millionth* part of the distance of the observer was made visible. One result of the experiments would be to show what would be the proper proportions of parts to be observed in forming *letters* to be read with the greatest distinctness at a distance,—a subject of much practical use in the present day, and admitting of a strictly scientific system, although generally left to the fancy of incompetent persons. *White* letters on a *black* ground should have their component lines of only half the breadth that *black* letters should have on a *white* ground.

The direction of the eye, while appearing to gaze *steadily* at any object, does in reality keep *wandering* to an imperceptible distance on every side of the object looked at, but very rapidly. This *wandering* is not accidental or an imperfection of sight, but an essential feature of vision; because it is not the *continuance* of an impression that is perceived (by any of the animal nerves), but its commencement and termination, or, more strictly speaking, its increase and decrease. This principle is probably analagous to that by which a magnet creates an electric current in a neighbouring wire, not by its *constant presence*, but by the increase or diminution of its influence, either by a variation of its *power*, or of its *position*.

This wandering propensity of the eye was shown to account for the relative facility with which different sorts of marks were seen at great distances: it takes place, apparently, in a minimum case, to the extent of an angle of 1 in 2500. A dislocated line (as in a vernier), its *fault* being half its breadth, can be perceived to be so at a distance of 10,000 times its fault, if black on a white ground; and at 12,000 times, if white on a black ground. It shows itself, however, by giving the line a *less steady* appearance, than a perfectly even line would have, when narrowly watched, by running the eye along the line, at about half as far again.

Experiments were then described, on the visibility of the positions of the *ends* of lines, and of *hiatuses* in lines, and of *square* dots as compared with round. But the last conclusion of practical importance was in respect of observing the angular position of station-marks, or of stars, by reflection, as in a sextant. From these experiments it appeared that the position of two closely adjacent dots or images, in sensible parallelism to a given direction, while it affords one of the *simplest* kinds of observation, is more accurately observable than their actual coincidence, or even than the junction of two lines, as if in a vernier.

On the Gradual Subsidence of a Portion of the Surface of Chat Moss, in Lancashire, by Drainage. By Mr. G. W. Ormerod.—This was the continuation of a paper read at the Swansea Meeting. It was shown by a series of levellings made in the last four years, over an extent of about 200 acres, where drainage was carried on, that a subsidence had taken place to the amount of one inch per annum.

ELASTICITY OF SOLIDS.

On the Laws of the Elasticity of Solids. By W. J. Macquorn Rankine, C.E., F.R.S.E.

This paper is intended to form the foundation of the theoretical part of a series of researches on the strength of materials. Its immediate object is to investigate the relations which must exist between the elasticities of different kinds possessed by a given substance, and between the different values of these elasticities in different directions.

The different kinds of elasticity possessed by a solid substance are distinguished into three, viz.:— First, *longitudinal elasticity*, representing the forces called into play in a given direction by condensation or dilatation of the particles of the body in the same direction; Secondly, *lateral elasticity*, representing those called into play in a given direction by condensation or dilatation of the particles of the body in a direction at right angles to that of the force; and thirdly, *transverse elasticity* or *rigidity*, being the force by which solid substances resist distortion or change of figure, and the property which distinguishes solids from fluids. The author's researches refer chiefly to substances whose elasticity varies in different directions. His first endeavour is, to determine the laws of elasticity of such substances, so far as they are independent of hypotheses respecting the constitution of matter; a course which has not hitherto been followed.

The *first Theorem* or law states the existence of three axes of elasticity at right angles to each other at each point of each substance possessing a certain degree of symmetry of molecular action. The elasticity of a body, as referred to these three axes, is expressed by twelve coefficients, three of longitudinal elasticity, six of lateral elasticity, and three of rigidity, which are connected by the following laws.

Theorem II. The coefficient of rigidity is the same for all directions of distortion in a given plane.

Theorem III. In each of the co-ordinate planes of elasticity, the coefficient of rigidity is equal to one-fourth part of the sum of the two coefficients of longitudinal elasticity, diminished by one-fourth part of the sum of the two coefficients of lateral elasticity in the same plane.

The investigation having now been carried as far as is possible without the aid of hypotheses, the author determines in the first place the consequences of the supposition of Boscovich, that elasticity arises solely from the mutual action of atomic centres of force. In the following theorems a *perfect solid* means a body so constituted.

Theorem IV. In each of the co-ordinate planes of elasticity of a perfect solid, the two coefficients of lateral elasticity, and the coefficient of rigidity, are all equal to each other.

Theorem V. For each axis of elasticity of a perfect solid the coefficient of longitudinal elasticity is equal to three times the sum of the two coefficients of rigidity for the co-ordinate planes which pass through that axis, diminished by three times the coefficient of rigidity for the plane normal to that axis.

Thus in perfect solids all the coefficients of elasticity are functions of *three* independent coefficients—those of rigidity. In no previous investigation has the number of independent co-efficients been reduced below *six*.

To represent the phenomena of *imperfect* solids, there is introduced the *hypothesis of molecular vortices*, in addition to that of atomic centres; that is to say, each atomic centre is supposed to be surrounded by a fluid atmosphere, retained round the centre by attraction, and diffused from it by the centrifugal force of revolutions constituting *heat*. The author has already applied this hypothesis to the theory of the elasticity of gases and vapours. (Trans. Roy. Soc. Edin., Vol. XX. Part I.) Applied to solids, it leads to the following conclusions:—

Theorem VI. In an imperfect solid, each of the coefficients of longitudinal and lateral elasticity is equal to the same function of the coefficients of rigidity which would have been its value in a perfect solid, added to a coefficient of *fluid* elasticity which is the same in all directions.

Thus the number of independent coefficients for such substances is *four*.

The rest of the paper is occupied by the deduction from these principles of some important consequences, relative to coefficients of compressibility and extensibility, and to elasticities corresponding to directions not coinciding with either of the three axes.

FORCE OF WAVES.

Observations on the Force of the Waves. By Thomas Stevenson, F.R.S.E., Civil Engineer.

The author, after some introductory remarks, described the action of the Marine Dynamometer, the self-registering instrument with which the observations were made, and one of the instruments was exhibited. He stated, that a theoretical objection might, perhaps, be started to referring the action of the sea to a statical value, but contended, that in designing sea works the attempt of the engineer is to oppose the dynamical action of the sea by the dead weight or inertia of the masonry, so that the indications of the Marine Dynamometer furnish exactly the kind of information which the engineer requires. The greatest result registered in the Atlantic Ocean was at Skerryvore, during the westerly gale of the 29th of March, 1845, when the force was 6083lb., or 3 *tons per square foot.* The greatest result registered in the German Ocean was 3013lb., or about 1½ *ton per square foot.* It further appeared, from taking an average result for five of the *summer* months during the years 1843 and 1844, that the force in the Atlantic Ocean was 611lb. per square foot, while the corresponding average for six of the *winter* months was 2086 lb., or three times as great as in summer. These observations he had communicated in 1845 to the Royal Society of Edinburgh, and were printed in the twelfth volume of the 'Transactions' of that body.

The author then stated, that the greatness of those results had excited surprise in almost all to whom they had been communicated, and positive doubts were expressed by many as to the correctness of the indications. Three classes of facts, essentially different from each other, may be appealed to, as proving that if the indications of the Dynamometer are incorrect, the error must be in defect, and not in excess. The first fact to which reference was made was the elevation of spray caused by waves meeting with an obstruction to their onward motion. Most persons are familiar with the frontispiece representations of the Eddystone and Bell Rock Lighthouses during storms, which are attached to the descriptive accounts of the erection of those works; and although some deduction may be allowed for the fancy of the artists, still there can be no doubt that they are, in the main, faithful representations of a natural phenomenon. On the 20th of November, 1827, in a heavy ground swell after a storm, solid water rose at the Bell Rock, 106 feet above the level of the sea, irrespective of the depth of the trough of the wave. Such an elevation is due to a *head* of water of the same height. The force, then, which urges the lower courses of the Bell Rock must have been *nearly three tons per square foot*, while the highest indication of the Marine Dynamometer at the same place, since the observations were commenced hardly *equalled* 1½ *ton.* The second class of facts to which the author alluced was the fracture of materials of known strength. The instance adduced was a small harbour in Argyllshire, where, in order to preserve the tranquility of the tide basin, a contrivance, called '*booms*,' well known in harbour architecture, had been resorted to. The booms are logs of timber, which are placed across the entrance to a harbour, and fit into checks or grooves, which are made in the masonry on either side. The booms, therefore, act as a temporary wall or barrier against the waves. The set of booms referred to have been in use for about five years, and in that time the waves have broken no less than four Memel logs, measuring each one foot square in the middle, and spanning an entrance of 20 feet. From the known strength of the material it will be found, that on these four occasions a force must have been exerted equivalent to the uniform distribution of a dead weight of 30 tons, or *at the rate of* 1½ *ton per square foot*, while the highest result that had been recorded at the same place during the short period that observations were made, was about 1⅛ *ton per square foot.*

The last class of effects to which the author alluded was the movement of heavy blocks of stone. The information derived from such observations was not so certain or satisfactory as from the other instances. The only record he could adduce was the movement of a block of stone *weighing about* 1¼ *ton*, to which a Marine Dynamometer had been bolted. The stone was turned upside down, and the dynamometer indicated a pressure of *little more than one ton.*

The author then referred to the overturning of the Carr Rock Beacon by the sea in 1817, during a heavy gale, but stated that, as we do not know the manner in which waves act when encountering obstacles, it was impossible to calculate what force had in this instance been exerted. The part of the column which was over-turned was 36 feet in height, and 17 feet in diameter at the base, the rock being so small as to preclude a greater diameter. The author then concluded by stating the following desiderata, which he thought important:—

1st. Continued observations so as to ascertain *constants* for the Atlantic and German Oceans and the Irish Sea.

2nd. Relative forces of the same wave both above high-water and below low-water levels. And

3rd. Relative forces of the same wave against vertical and sloping surfaces.

AIR AND WATER IN TOWNS.

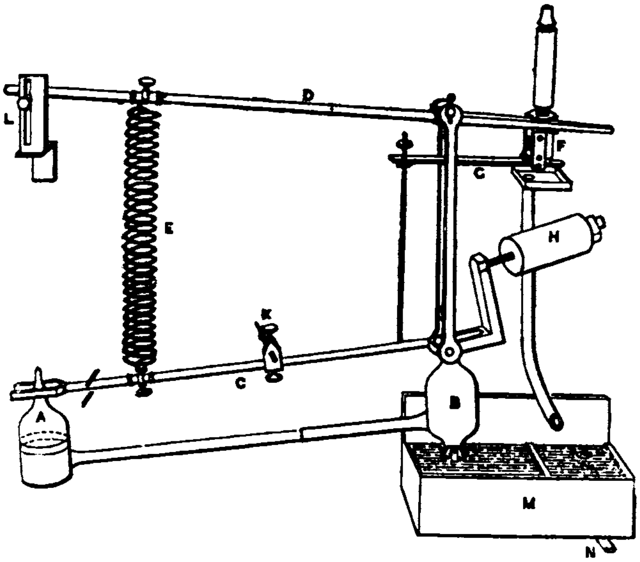
On the Air and Water in Towns, and the action of Porous Strata on Water and Organic Matter. By Dr. R. A. Smith.

It is a matter of great importance to find from what source it is best to obtain water for large towns, and how it is to be collected. To these points Dr. Smith particularly directs attention. Regarding the conditions of many springs, which never become muddy, but possess a constant brilliancy and a very equal temperature at all seasons of the year, the author thinks that there is a purifying and cooling action going on beneath. The surface water from the same place, even if filtered, has not the same brilliancy; it has not the same freedom from organic matter, neither is it equally charged with carbonic acid or oxygen gas,—there are other influences therefore at work. The rain which falls has not the purity, although it comes directly from the clouds; it may even be wanting in cleanness, as is often the case. Springs rise through a great extent of soil, and collect a considerable amount of inorganic salts; and it is shown by Dr. Smith that their purity is due entirely to the power of the soil to separate all organic matter, and at the same time to compel the mixture of carbonic acid and oxygen. The amount of organic matter removed in this way is surprising, and it is a most important and valuable property of the soil. The change even takes place close to cesspools and sewers; at a very short distance from the most offensive organic matter there may be found water having little or none in it. As an agent for purifying towns, this oxidation of organic matter is the most extraordinary, and we find the soil of towns which have been inhabited for centuries still possessing this remarkable power. St. Paul's Churchyard may be looked upon as one of the oldest parts of London, and the water from the wells around it is remarkably pure, and the drainage of the soil is such that there is very little of any salts of nitric acid in it. If the soil, says Dr. Smith, has such a power to decompose by oxidation, we want to know how it gets so much of its oxygen. We must, however, look to the air as the only source, and see how it can come from it. When water becomes deprived of oxygen, it very soon takes it up again,—as may be proved by experiment. This shows us that as fast as the oxygen is consumed by the organic matter it receives a fresh portion, conveyed to it by the porous soil. Several experiments of the following character were given, to show the filtering power of the soil:—A solution of peaty matter was made in ammonia; the solution was very dark, so that some colour was perceived through a film of only the twentieth of an inch in thickness. This was filtered through sand, and came out perfectly clear and colourless. Organic matter dissolved in oil of vitrol was separated from it by a thickness of stratum of only 4 inches. A bottle of porter was by the same process deprived of nearly all its colour. The material of which this filter is made is of little importance. One of the best, according to Dr. Smith, as far as clearing the water is concerned, being of steel filings; oxide of iron, oxide of manganese, and powdered bricks, all answer equally well. This shows that the separation of the organic matter is due to some peculiar attraction of the surfaces of the porous mass presented to the fluid.

REGISTER HYGROMETER.

This instrument was invented by Mr. Appold, for the purpose of keeping the atmosphere of his house, in Finsbury-square, at one regular degree of moisture. It is made so that a variation of one-quarter of a degree in the hygrometric state of the atmosphere will open a valve capable of supplying ten quarts of water per hour, and convey it on to the surface of warm pipes covered with blotting paper, by which the water is evaporated until the atmosphere is sufficiently saturated, and the valve thereby closed.

A lead pencil K, attached, registers the distance the hygrometer travels, and thus a sheet of paper moved by a clock would show the hygrometric state of the atmosphere at any period of time. The instrument is made with two bulbs, A and B, of a cylindrical shape, 1 inch diameter and 1¼ inch long, placed vertically, so that the surface of the mercury may always be the same size; the bulbs are about 9 inches apart, with mercury enough in them to fill one, and connected together by a glass tube, that the mercury may flow freely from one to the other. A little ether is placed in each bulb, and the remaining space filled with the vapour from the ether. The bulbs are fixed upon a balance. so that when one bulb becomes warmer than the other, the ether forms vapour in one, and condenses in the other, by which means the mercury is driven from one bulb to the other.



It will be observed that the wet bulb B, is placed under the fulcrum, for the purpose of keeping it always in contact with the water; the other end A, is held up by a spring E, connecting the two horizontal levers D, and C, so that it can be adjusted to agree exactly with the action of the mercury: this is done with both bulbs dry, and made to stand in any position, the spring counteracting the weight of the mercury. When in use, the spring and levers are lowered, allowing as much mercury to flow into the dry bulb as may be required; the drier the atmosphere is required to be, the lower the dry bulb must be placed. The valve F, is fixed to one end of the top lever D, that the lever G, which opens the valve, may be always in the same situation relative to the hygrometer. In the place to which it belongs the water is laid on with a gutta-percha pipe. The brass vessel at top serves for a temporary cistern, to show the action of the valve. H, weight attached to the lower lever C: L, set screw for upper lever; M, cistern that receives the water from the valve, the overflow of which goes on to the pipes; N, overflow pipe.

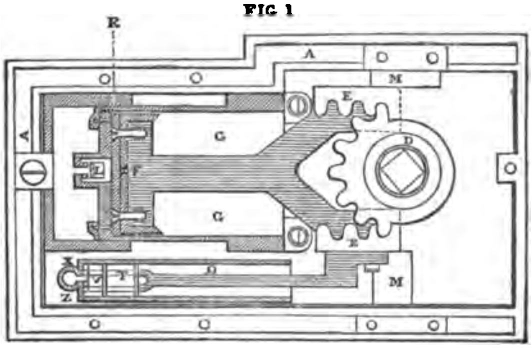
DOOR SPRING HINGE.

An improved Door Spring. Invented and patented by George Beattie, builder, Edinburgh.

In all steel springs there is a defect in the want of uniformity of pressure throughout the travel of the door, which usually increases as the door is opened wider, and makes it disagreeable to the person opening it; and when it closes, a rapid slam takes place; and if the door has glass in it, it is liable to be broken. By the improved hinge these defects are avoided, and there is no metal spring of any kind used, the motive power being obtained by the pressure of the atmosphere (which is well known to exert a pressure of 15 lb. to the square inch) acting on one side of a piston; the other side being a vacuum. In applying this pressure to shut a door, about 2 lb. to the square inch is lost by the friction of the machinery. The pressure of the air acts simply as a counterbalance on the piston, the resistance being uniform throughout the travel of the door when opening it, and when shutting the door the regularity of motion and avoiding of slam is obtained by means of a stream of oil being made to discharge from a cylinder through a large or small aperture, according to the speed required. Fluids being almost incompressible, the oil will not pass through the aperture beyond a given rate, which is in proportion to the size of the aperture and the quantity to be discharged, and the power of the cylinder the vacuum is formed in to press it through. There is nothing in the machinery employed liable to break or get out of order.

The air-spring consists of an iron box and cover A, let into the floor, which contains a vertical axle B, supported at bottom in a hollow cup C, and furnished at the top end which projects above the floor with a shoulder and lever hinge P, for carrying the door on this axle; and within the box is fastened a horizontal wheel D, which is toothed upon a portion of its circumference. On each side of this wheel is a rack E, attached to a piston F, which is made to fit tightly into a cylinder G, by a cap leather H. In the under side of the cylinder is a valve K, communicating with the outside; in the bottom of the cylinder is another valve L, communicating with an exhausted chamber. On each side of the racks are guides M, for the piston.

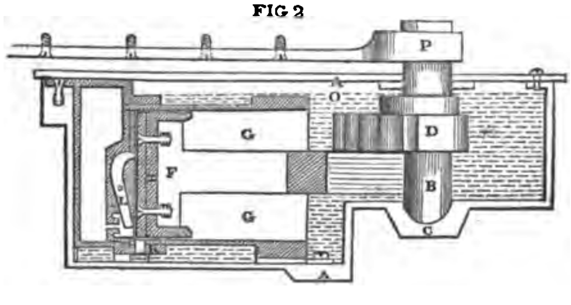
FIG 1



PLAN.

The teeth of the wheel are made to take in either of the toothed racks as the door or gate is opened one way or other, so that the piston will be drawn along the cylinder, leaving a vacuum behind at a uniform and regular degree of resistance until the door is released, when the unbalanced pressure of air upon the face of the piston will cause the door to resume its original position.

FIG 2

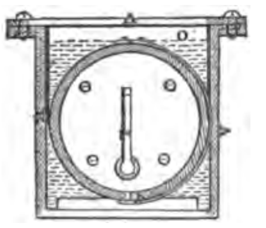


VERTICAL SECTION.

The use of the valve K, communicating with the outside of the cylinder is that, in case of a leakage of air behind the piston, it shall be driven by the return of the piston through it to the outside.

The use of the exhausted chamber and valve L, communicating with it is, that a small portion of the leakage air or oil which cannot be discharged through the valve K, leading outwards, escapes into the exhausted chamber, which allows the piston to get to the bottom, and to bring the teeth of the rack in hard contact with the teeth of the wheel, and thereby keep the door in its proper place when shut; in fact, gives it a maintaining power.

FIG 3



VERTICAL TRANSVERSE SECTION

The regulator is for tempering the speed of the door when shutting. It consists of a small cylinder Q, with a piston T, made to fit tightly into it by hemp packing; in the piston T, is a conical valve V, opening inwards to charge the cylinder with oil when opening the door. This valve closes when the door begins to shut. At the end of the cylinder Q, is another valve, or what is commonly called a cock, which regulates the discharge of the oil which passed into the cylinder during the opening of the door. According to the size of the aperture Z, in the cock, so is the time it takes to discharge the oil, and so is the speed of the door in resuming its position when shut, which completely prevents the motion increasing beyond what is wanted, and avoids slamming.

The box requires to be filled with lard or sperm oil up to the dotted line O, to seal the piston and keep the whole lubricated.

These hinges have been used for some of the public establishments in Edinburgh with success.

ELASTICITY OF CAST-IRON.

The Hyperbolic Law of Elasticity of Cast-Iron. By Homersham Cox, B.A. Jesus College, Cambridge.

The object of this paper was to show that the extension and corresponding tensile force of a cast-iron rod are related to each nearly as the ordinates of a hyperbola. That the tension and extension are not directly proportional, but that there exists what is termed a *defect of elasticity* was shown by Leibnitz, James Bernouilli, and others.

The real law of elasticity of any material can be ascertained only by direct experiments, and differs slightly even for two different specimens of the same material. All, therefore, that can be done in expressing the law by a formula is to represent the average of several experiments. The results of a set of experiments can be represented with any required degree of accuracy by a formula expressing the weight by ascending integral powers of the corresponding extension. The ordinary law stops at the first term of the series; and the modification which most readily suggests itself is to extend the series to the second term; so that if e be the longitudinal extension of a cuniform rod, w the weight producing it, and A and B empirical constants,

$$w = Ae - Be^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

From the experiments recorded in the Report (1849) of the Commission "appointed to inquire into the application of Iron to Railway Structures," it is manifest that the formula (1) adopted in the Report is subject to unavoidable inaccuracies. Eight formulæ are given for extension of different kinds of iron; and it is observable in each case, without exception, that at least one-half, and generally more, of all the results of each set come together in the middle of the series with the errors in excess, and are preceded and followed by results in which the errors are in defect. The general character of the errors is therefore this—they are at first negative, then positive, and increasing in magnitude up to some term near the middle of the series. They then decrease till they become negative again. It may be shown by simple algebraical reasoning that the error may be nearly expressed by the first, second, and third powers of the weight; and this expression, added to the original formula, gives a *cubic* formula which is more correct than either the quadratic or bi-quadratic formula as obtained in the Report.

All these formulæ lead to very complicated results in their mathematical applications. That, however, which is here proposed, possesses the advantage of far greater simplicity combined with accuracy greatly exceeding that of the quadratic formula.

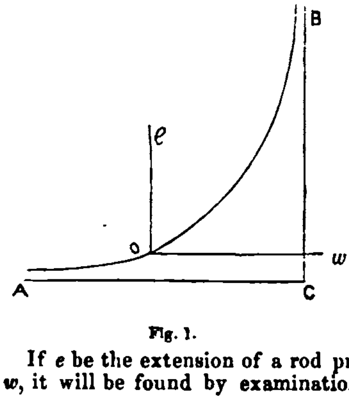


Fig. 1.

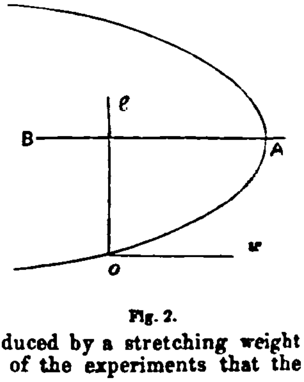


Fig. 2.

If e be the extension of a rod produced by a stretching weight w, it will be found by examination of the experiments that the relation between e and w may be closely expressed as follows:—

$$w = \frac{a e}{1+\beta e}; \qquad \text{or, } e = \frac{w}{a-\beta w};$$

which is the equation to a rectangular hyperbola of which e and w are the co-ordinates. Let (fig. 1) CA, CB, be the asymptotes; then referring to the above equation, e and w will be measured along the axes oe, ow, respectively, o being the origin.

Similarly, the formula $w = \mathrm{A}e - \mathrm{B}e^2$ is the equation to the parabola (fig. 2); oe, ow, are the axes of e and w; AB the axis of the curve, and A its vertex.

The formula now proposed may be therefore considered to exhibit THE HYPERBOLIC LAW OF ELASTICITY, and the last-mentioned formula THE PARABOLIC LAW, in consistency with the nomenclature adopted by James Bernouilli in the 'Acta Eruditorum' of Leipsic, 1694. In the tables accompanying this paper, comparison is made between the two formula for cases of extension and deflection; the accuracy of the former is shown to be always the greatest—the error of the parabolic formula being, on the average, between three and four times as great as that of the hyperbolic formula.

Assuming, then, the proposed expression for the extension of a rod of a unit of length and a unit of sectional area, and the analagous one for compression (d), by a weight (w),

$$w = \frac{\gamma d}{1 + \delta d}$$

It is fonnd that the deflection f, of a rectangular beam of length $2a$, of depth $2d$, in the direction of deflection, and width μ, by a force $2\mathrm{P}$, applied perpendicularly at the centre of the beam, is

$$f = \mathrm{P}a^3 \div \left\{\mu d^3(a+\gamma) - \frac{27}{16}\,\mathrm{P}ad\,\frac{a\beta + \gamma\delta}{a+\gamma}\right\},$$

which is the hyperbolic formula for deflection.

Hence, an expression is deduced for the ultimate deflection of rectangular beams, from which it follows that their strength is as their thickness and the cube of their depth directly, and as the length inversely—the law usually adopted in practice hitherto. It is true that this law was not formed to be followed exactly in the experiments above referred to, where the magnitude of the beams differed greatly; but the irregularity is explained in the Report as due principally to the superior hardness of small castings.

Lastly, by substituting in the above formula for the deflection numerical values of f, a and β, obtained from the experiments on extension, the numerical co-efficients are obtained in the formula for compression. This method seems to tend to more correct results than the experiments on direct compression, detailed in the Report. For those results are extremely irregular, and were vitiated by the inclosure of the compressed rod in rectangular tubes, the sides of which were pressed by the rods when they became bent; and this pressure had great effect to resist the compressing force at the end of each rod. The numerical values of the co-efficients of compression in the hyperbolic formula agree closely together when computed, by the above-mentioned method, from experiments on deflection of different bars.

The great desideratum for the improvement of the hyperbolic or any hypothetical law of elasticity is a knowledge of the manner in which the strength of cast metal is influenced by the magnitude of the casting; and it is to be hoped that this defect of practical knowledge will not long remain unsupplied.

VALUE OF WASTE GASES FROM BLAST FURNACES.

On the Value of the Gaseous Escape from the Blast Furnaces at the Ystalfera Iron-works, in Wales. By Mr. Palmer Budd.

Mr. Budd stated that, since the meeting of the Association at Swansea, he had continued, and with increased success, to apply the waste gases that escaped from the top of blast furnaces, to the manufacture of iron; and it was the result of his farther experience applied to the whole of his furnaces (nine in number) since that period, that he now wished to submit to the Section. He considered that he could not have fallen on a better locality for this purpose than Scotland, where the iron trade has been developed with a rapidity that is quite surprising, and quite characteristic of the enterprise of Scotchmen. Twenty-five years ago, Scotland was of no importance in the iron trade, but since then the produce of iron in Scotland had increased to between six and seven hundred thousand tons a-year. In that short period Scotland had accomplished a production which Staffordshire and other places in England took two hundred years, and South Wales a hundred years to accomplish—the make of iron in Scotland being now equal to that of either England or Wales. This great accession to the produce of iron has had a sensible effect on its price; but as he believed that necessity was the mother of invention, and that nature had in store for us an immense reservoir of riches to be yet developed, he was of opinion that the tendency of all this cheapness was to teach us that nothing should be wasted, and that we should look forward to the time when the smoke that at present contaminated the atmosphere, and the filth that polluted our streets, would be regarded as too valuable to be wasted.

When we considered the utility of iron, its low price, and its general distribution in the deposits of every age, we could not but look upon it otherwise than as the great agent in modern civilisation.

Mr. Budd then referred to his mode of applying the gaseous escape, and said it was well known that there were two descriptions of furnaces used for metallurgic purposes. The one was the blast furnace, into which air was injected, by mechanical means, at a great density, so as to penetrate upwards of forty feet of dense materials; and the other the reverberatory furnace, where the fire was produced by means of the draught of a chimney stack. What he had accomplished was by combining these two, so that the gaseous products of the furnace, instead of escaping through the funnel head, were drawn sideways by a high stack, and passing through the stoves and boilers, leave behind the necessary temperature of the blast and of the steam. In a blast furnace the ores are smelted before the *tuyeres* by the conversion of the solid carbon into carbonic acid, which, passing up through the middle region of the furnace into a bath of carbon, was reconverted into carbonic oxide, capable of combining with a farther dose of oxygen. It would be thus seen that the whole of the carbon of the fuel should be present at the top of the furnace in a gaseous form. When the British Association met at Swansea, he had not used the gaseous escape at any great distance from the furnace, his stoves and boilers being very closely contiguous. Further experience, however, had proved that by the aid of a stack at the end of the chain of sufficient dimensions, the gaseous escape from the furnace might be made to travel in the most tortuous directions, descending to the stoves built for heating by the usual fire-places, and traversing the boilers; the only condition absolutely necessary being that there should be an unbroken communication with the high stack at the end, into which the gaseous escape might at last pass, and by which it was drawn forward, instead of passing off wastefully at the funnel-head. When, however, the draught was carried downward, and to long distances, he had found it necessary to drop into the top of the furnace a hopper or funnel, made of sheet-iron, which acted as a shield at the mouth of the horizontal flues, and prevented them from either being affected by high winds, or from being choked up by the materials thrown into the furnace.

The reason, no doubt, why this funnel was not applied before was the great apparent temperature at the funnel-head. In practice, however, it was found that until the gaseous escape mingled with the atmosphere, its heating power was not such as to injure sheet-iron, or even to make it red hot. In fact, so long as there was an escape upwards, the iron funnel would not be injured. The damage arose during and after stoppages of the furnace, when the blast was obstructed in its passage upwards by the settlement of the materials in the furnace, so that the atmosphere rushed down to meet the ascending gases, and of course, caused a very high local temperature. His practice was to exclude the atmospheric air as much as possible. The affinity of the gases for oxygen was so great that the air leakage raised the temperature quite sufficient for safety, whilst the full combustion of the gaseous escape would melt down the bricks in the flues, and destroy the texture of the iron tube. It was not possible for him to say what combinations took place at high temperature, where carbonic oxide, carbonic acid, hydrogen, and nitrogen, were mixed in such proportions. At any rate, he found a smothered combustion to be the most suitable and economical for the purposes in view.

He was happy to say that, at length, the application of the gaseous escape had been tried in Scotland; and that at Dundyvan and elsewhere it was now in successful operation. The peculiar quality of the furnace coal of Scotland being what was called in South Wales "free burning," which, when put into the furnace raw, coked sufficiently in its descent, gave out an enormous escape, so much so that, upon a rough estimate, he calculated that the waste from one furnace in Scotland was sufficient to heat the blast, and to raise the steam for three. With anthracite coal, the minimum effect was obtained, as it was a dense fuel of nearly 95 per cent. of solid carbon; but in Scotland there would be an enormous surplus at the funnel-head.

He expected, from the well-known sagacity of the Scottish people, that when truly embarked in this mode of operation the greatest possible use would be made of it: and he would not be surprised to see heat let out, like mill-power, for burning bricks and other similar purposes. He felt, however, anxious that the application should be made under the superintendence of competent parties, as he had known several instances where the plan had been abandoned from difficulties that might easily have been surmounted under proper directions. He was quite aware that, by the plan he had pursued, the utmost heat was not extracted from the gases; and that, by different means, a temperature might be obtained capable of performing all the operations of the forge; and if it be true that the solid carbon of the furnace in its escape, as carbonic oxide, would unite with another dose of oxygen for saturation, there could be little doubt that, with properly constituted gas furnaces, there was enough at present passing off to convert the pig iron into bar iron. He hoped some of the ironmasters of Scotland would follow up this hint effectually with regard to the remaining processes required for making malleable iron. He observed that the saving at the Dundyvan Iron-works was stated to be about 1¼ ton of coal for each ton of iron produced. Supposing, therefore, 600,000 tons of iron to be the produce of Scotland, and supposing the value of the coal used to be 3*s.* a ton, the saving that would thus be effected on the make of Scotland would amount to 112,500*l.* a-year; to which might be added 20,000*l.* a-year of saving in wages and repairs, which would make a total saving of 132,500*l.*, or about 4*s.* 5*d.* a ton on the produce of Scotland, which on the present price of 44*s.* per ton, was about 10 per cent. on the value. If the gaseous escape could be extended to the uses of the forge, a farther saving of three tons of coal would be effected—thus making, at least, a saving of 20*s.* a ton on all the iron manufactured into bars, sheets, and rails.

ELECTRICITY AND HEAT AS MOVING POWERS.

On the Application of Electricity and Heat as Moving Powers. By Mr. PETRIE.

FROM the dynamic equivalent of electricity, we can infer an important fact that one-horse power is the theoretic or absolute dynamic force possessed by a current of electricity derived from the consumpt of 1·56 lb of zinc per hour in a Daniells' battery. But the best electro-magnetic engine that we can hope to see constructed cannot be expected to give more than half or a fourth of this power; in any case we see here the limit of power which no perfection of apparatus can make it exceed. The peculiar mode in which the electric current produces dynamic effects has led to much miscalculation respecting the power obtainable from it. In any sort of electric engine the material to which the neighbouring current gives motion, whether it be another moveable current, or, what is more usual, a magnetic body, is impelled in one direction with a constant force, and this force, whether it be attraction, repulsion, or deflection, is, like the powers of gravity, sensibly constant at all velocities, however fast the body recedes before the action of the force, provided only the same quantity (per minute) of electric current be maintained. This is quite different from the action of steam power, in which the faster the piston moves the greater is the volume of steam per minute that must be supplied to move it, or else the less will be the power with which it moves. —This fact, then, that the force with which an electric current of a given quantity moves the machine, is the same at any velocity of motion, bears no analogy to the case of steam, but would indicate that the dynamic result obtainable from a given electric current might be infinitely great; and so it would be, were it not that the part moved always tends to induce a current in the wire in the reversed direction, and this inducing influence, which increases with the velocity of motion, conflicts with the original current and reduces its quantity, and consequently reduces the power of the motion, as well as the consumpt of materials in the battery. Some have imagined that possible alterations in the position of the parts of the machine, or in its mode of action, would avoid the evil, or even might make the induced current to flow with the primary current instead of against it; the impossibility of this, though not readily proved in detail, can be at once proved by reference to general principles. It would, if true, be a creation of dynamic force—the evolving an unlimited force from a limited source. The tendency to an opposing induced current in the primary wire must, therefore, be involved in the very principle of the system; so that no ingenuity can ever get rid of the retarding influence of the induced action; and the only way to overcome its power, so as to maintain the primary current from falling below a given rate or quantity when the machine is allowed to attain rapid motion, is to increase the electro-motive power of the battery, the intensity (not the quantity) of the current, so that it should be less affected by the opposing induction.

The practical importance of these not altogether unknown truths, may justify the above somewhat particular notice of them. For want of a clearer apprehension of them, inventors have misapprehended the direction in which improvements were to be made and much ingenuity and means have been wasted.

Some of the best electro-magnetic engines of other inventors that have been properly tested by the author and others, on a practically useful scale, have only given a power at the rate of 50 to 60 pounds of zinc per horse-power per hour. The smallness of this power in comparison with the absolute value of the current (1·56 pound of zinc per horse-power per hour) should not occasion surprise if we consider the present case of steam after many years of improvement.

According to the determinations of Youll and of Rankine on heat, one pound of water raised one degree of temperature, is equivalent to 700 lb. weight raised one foot. The author then proceeded to show that the best Cornish engines only yield $\frac{1}{14}$th of the power that the combustion of the carbon actually represents, and many locomotives only $\frac{1}{100}$th part;—showing what great rewards may yet await the exercise of inventive genius in this department, and that we need not wonder that we have, as yet, only obtained $\frac{1}{32}$nd part of the power possessed by electricity. But it is to be remembered that there is a far greater likelihood of obtaining a larger proportion of the real power from electricity than from heat, owing to the character of the two agents.

Mr. Petrie then proceeded to explain the reasons why so little of the power of heat could be obtained in a useful form, even in the best steam-engines, and what were the difficulties for invention first to overcome in order to a better result.

In the case of electricity, however, there is no analogous difficulty; but we have instead, the difficulty and expense of developing current electricity by the chemical actions now requisite. If carbon could be burnt or oxidised by the air, directly or indirectly, so as to produce electricity instead of heat, one pound of it would go as far as 9⅓ pounds of zinc (in a Daniells' battery) chiefly because there are as many atoms in one pound of carbon as there are in 5¼ pounds of zinc, and partly because the affinity (for oxygen) of each atom of (incandescent) carbon is greater than that of an atom of cold zinc, minus the affinity of the hydrogen for the oxygen in the water of the battery. Apart, however, from such prospects of improved means of obtaining electricity, its favourable feature, on the other hand, in comparison with heat, is, the reasonable expectation that we may obtain from electricity a considerable portion of the power which Mr. Petrie has determined as being the dynamic equivalent of the electric current.

REVOLVING LIGHTHOUSE LIGHTS.

On the Limits to the Velocity of Revolving Lighthouse Apparatus caused by the time required for the production of Luminous Impressions on the Eye. By WILLIAM SWAN, F.R.S.E.

THE object of this communication is to ascertain the greatest velocity that can be given to a revolving lighthouse apparatus, without impairing the brightness of the light. It is well known that at a given distance the apparent brightness of a revolving light exceeds that of a fixed one, supposing the intensity of the source of illumination to be the same in both cases; and this effect is due to the fact that the revolving apparatus collects all the light into beams of nearly parallel rays, which illuminate only a small portion of the horizon at any instant, while the fixed apparatus scatters its rays over every point in the horizon. The question might occur, is it possible to continue the superior intensity of the revolving with the constancy of a fixed light by increasing the velocity with which the apparatus revolves so as to cause its flashes to reach the eye in rapid succession? The attempt to combine in this manner the advantages of the two systems of lights was actually made by the late Captain Basil Hall, who, founding on the well known phenomenon of the persistence of impressions on the retina, conceived the ingenious idea of causing a revolving light to rotate so rapidly as to produce a continuous impression on the eye.

The practical efficiency of this arrangement was tested by Mr. Alan Stevenson; and the result of his experiments is described in his recent work on the Skerryvore Lighthouse.* An octagonal frame, carrying eight lenses, was made to revolve with various degrees of rapidity, and the light was observed at a distance of 14 miles. It was then found, that as the rate of revolution was accelerated, the apparent brightness and volume of the flashes diminished; until when a velocity of eight or ten flashes in a second was obtained—the light became almost invisible. Mr. Stevenson correctly explains this result by supposing, that when the lenses revolved rapidly the light had not sufficient time to produce its full effect on the eye. While these experiments sufficiently prove the impossibility of obtaining the result Captain Hall had in contemplation, yet in the absence of definite information regarding the connection which subsists between the apparent brightness of an object, and the time during which its light has acted on the eye, it is obviously impossible, without actual trial, to assign the limit to the velocity of a revolving light. This information is supplied by the author's researches on the time required for the production of luminous impressions on the eye, published in the 'Transactions of the Royal Society of Edinburgh' for 1849. His experiments were conducted by means of an apparatus, consisting of two screens, each with circular apertures an inch in diameter, to which are fitted pieces of ground glass. The apertures are illuminated by gas burners, which admit of having their distances from the screens varied at pleasure, by sliding their supports along the plank in a groove cut in it for that purpose. The brightness of the apertures in the screens is observed by means of a rectangular prism of glass placed half-way between them, with its faces inclined at angles of 45° to the line joining their centres. By this means the apertures are seen in apparent contact, and their relative brightness can thus be compared with great nicety. A disc is made to revolve on the axes in front of one of the screens, having a sector of a known angle cut in its circumference; and in this manner the aperture is seen for a short interval of time at each revolution of the disc. The time during which the light acts on the eye is easily ascertained, by knowing the velocity of the disc, and the ratio the arc of the sector bears to its whole circumference.

Before causing the disc to revolve, the apertures in the screens are made equally bright by varying the distance of the light from the screen. When the disc is then made to revolve, the apparent brightness of the aperture behind it is instantly diminished; and the equality of the brightness of the apertures in the screens is restored by increasing the distance of the light from the screen. The ratio of the brightness of the impression produced by the light during the revolution of the disc to the brightness of the impression when seen by uninterrupted vision, is that of the squares of the distances of the light from the aperture before and during the revolution of the disc. By means of this apparatus, it was found.—1. That when light of a given intensity acts upon the eye for a short space of time, the brightness of the luminous impression on the retina is sensibly proportioned to the time during which the light continues to act. Thus, the intensity of an impression made in ·01 seconds is almost exactly $\frac{1}{10}$th of the brightness of the light when seen by uninterrupted vision; and the intensity of the impression is exactly doubled in ·02 seconds.—2. Lights of every degree of intensity produce their impression on the eye with equal rapidity.—3. The time required to produce a complete impression is about one-tenth of a second.

The conclusion to be drawn from these experiments seems to be, that in any proposed revolving light, the velocity of rotation ought to be regulated so that the duration of each flash must at the very least exceed $\frac{1}{10}$th of a second. This velocity can be easily calculated, for the arc of the horizon, included by the brightest portion of the flash, is equal to the minimum divergence of the rays; and this, again, is equal to the angle which the horizontal diameter of the flame subtends at the edge of the aperture of the lens or reflector.†

If, then, t = the time of a complete revolution, t' = the duration of the flash, and a = the divergence of the rays, $t = \frac{2\pi t'}{a}$

Or, if we take $t' = \frac{1}{10}$th of a second as the shortest allowable diameter of the flash, we shall have $a\,t = 72$. Thus, in the case of the lens of Fresnel's revolving light of the first order, the minimum divergence is 4° 44′; and the greatest velocity of rotation that could be employed without necessarily diminishing the apparent brightness of the flashes would be 7·6, or nearly 8 seconds.

In like manner the greatest admissible velocity for a parabolic reflector, whose focal length is 4 inches, and its greatest double ordinate 21 inches, illuminated by a flame one inch in diameter, is one revolution in nearly 7 seconds.

In stating these cases, it is not of course assumed that so great velocities would be found suitable in practice. All that can be inferred from the experiments with certainty is this, that any proposed arrangement which should employ Fresnel's great lens with a velocity exceeding one revolution in 8 seconds, would necessarily be disadvantageous; or more generally, that in every lighthouse arrangement, care must be taken that the flashes of light have time to act on the eye for more than one-tenth of a second.

COOLING THE ATMOSPHERE OF ROOMS IN TROPICAL CLIMATES.

On a Method of Cooling the Atmosphere of Rooms in a Tropical Climate. By Professor C. Piazzi Smyth, of the Edinburgh Observatory.

The difficulty of effecting this object is so great, even in cooler countries, that while the apartment of a sick patient during winter is preserved carefully and easily, by means of a fire, at any desired temperature, if this be much exceeded during a few days in summer by the atmosphere, although the patient may visibly suffer from the heat, still the case seems to be thought so hopeless that the physician and friends are generally content merely to lament the untoward warmth of the weather; or, perhaps, in a few cases, to try to counteract some of the minor consequences of that prejudicial cause.

If the problem now proposed is to be solved in all its entirety, it must be stated thus:—

In a country where the thermometer stands at or above 80° Fahrenheit all through the 24 hours, both summer and winter, and where there can be no coolness in springs, wells, rivers, or the night air; and where *the atmosphere is saturated with moisture*, so that no cold can be produced by evaporation,—to lower the temperature of the air in rooms; to keep up a constant supply of pure cold air; and to remove that which has been warmed or otherwise vitiated.

To meet such a case, the present Indian methods are utterly inadequate, for the punkah, in its various forms, merely serves to agitate the air, and does not cool or purify it in the slightest degree. The wet mats which in some places are hung before windows, and being blown through, naturally or artificially, cool the transmitted air, would be inapplicable in the case now before us, where the air is saturated with moisture. And even where they can be employed, their use is objectionable on the ground of their adding so much moisture to air already overloaded with it; for it cannot be too strongly borne in mind, that in warm countries, though the air may often feel dry to the human frame, that still, on account of the air's capacity for moisture increasing with the temperature, there may be a far larger amount of watery vapour present than even in a Scottish mist.

And these are all the methods which have yet been brought forward for the relief of suffering humanity; for the bane to be removed is the too high temperature of the food of the lungs and the skin. The use of cold meats and iced drinks for the stomach must be regarded as a forlorn hope, and a mistaken idea.

A complete remedy would, however, seem to be presented in the property of air to increase in temperature on compression, and diminish on expansion—a fact strangely overlooked for this purpose, seeing how often workmen are stumbling upon it, while every book on Hydraulics contains an account of the Schemnitz machine, where air rushing out from great compression freezes the drops of water that issue with it; and every work on Natural Philosophy describes the syringes in which, by the sudden compression of air, tinder is ignited.

When cold air is to be produced in this way, it is evident that as the quantity of heat continually decreases for each succeeding atmosphere of pressure, it is desirable so to arrange the machine as to compress the greatest possible quantity of air the least degree necessary to produce the required temperature, than to obtain exceeding cold by compressing violently a small quantity of air, and diluting that afterwards with a larger quantity of common air.

After some consideration,* a compression of one-fourth an at-

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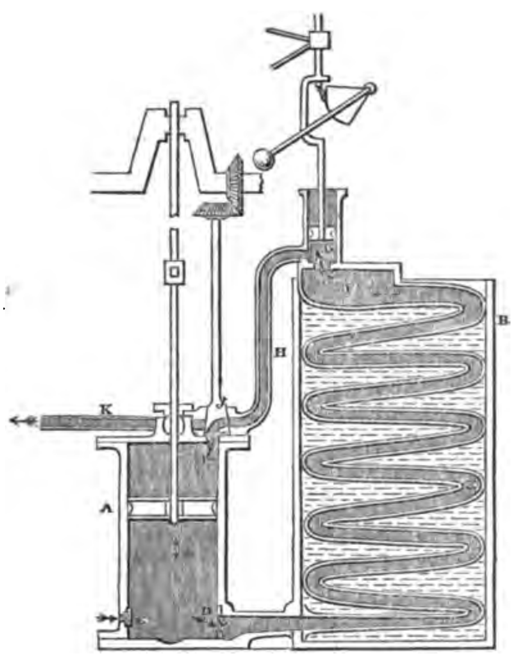
* See Stevenson's 'Account of the Skerryvore Lighthouse,' p. 313.

† See Stevenson's 'Account of the Skerryvore Lighthouse,' p. 318, 287.

* If machinery could be executed perfectly, a high degree of compression might be exerted, and the compressed and cooled air might be made to react in its expansion of the back of the piston which is compressing the air in front of it; thus saving all the power exerted but that lost in friction, diminished bulk of the cooled air, and imperfect expansion and leakage; but on submitting the matter to calculation, there did not seem to be any possibility of adopting the method with advantage in the present moderate degree of perfection of pneumatic engines.

mosphere has been thought to be sufficient in most cases; and the following arrangement of the machinery has been adopted for a one-horse power, which may be expected to furnish a room with about 80 cubic feet of air per minute, cooled 15° to 20° below the atmosphere outside. A double-acting air-pump, 9 inch diameter, and 18 inch stroke, making 60 double strokes per minute, with a jacket of cold water round the cylinder to mitigate the heat of friction, forces the air into the lower end of a coil of copper tube, contained in a tub of water, 3 feet diameter and 5 feet high, where the cooling is effected. At the upper end of the tube is a safety valve, which permits an escape of the confined air, when it exceeds 7 lb. on the square inch, into a larger tube, which at once conducts the now cooled air into the desired apartments. Where the work is constant, the piston should have a metallic packing, and the usual contrivance in stills should be adopted for changing the water of the worm tub.



A, air-pump; B, still worm tub; c, inlet air-valve; d, outlet valve for compressed air; e, worm-tub; f, chamber for compressed and cooled air; g, loaded valve to regulate compression; h, tube for expanded air; j, valve to regulate expansion; k, tube for conveying the expanded air to the room to be cooled.

The room to be filled with cold air should either be surrounded by a wall, unbroken by doors and windows, to at least 4 feet in height; or, which would be the better plan, should be sunk that, or a greater depth, in the ground. For the exit of the warm air, the opening of an upper sash of a window will be quite sufficient.

With regard to the power which is necessary to work the pump, a small steam-engine, though convenient as subserving a residual difficulty to be presently mentioned, would perhaps hardly be suitable but for a very few spots in India. A pair of bullocks would be the power most easily procurable in the greatest number of places, and at a very low rate. The manufacturer here should therefore send out with the pump a portable "horse-work," *i. e.* a small mill-work, such as horses or oxen might be applied to, and which by means of wheels and pinions or bands, should produce the necessary quickness of motion for the cranked axle of the pump. Where water-power is available, it should on no account be neglected; and in the majority of cases it is probable that the wind might be turned to good account.

So much for the sort of power by means of which the cooling apparatus is to be worked. But this being supposed to answer, a residual difficulty may be expected to arise in many cases—the cooled air will be found unpleasantly moist. This may be corrected by the natural tendency of air to deposit its moisture on metallic bodies colder than itself; and by making the tube which conveys the cooled air into the room pass through a still colder vessel of water, the moisture will be condensed on the inside surface of the metal, and may be conducted away by a subsidiary pipe. Where mechanical power is cheap, this vessel of water may be kept at the low temperature by passing through it air which has been compressed to a still greater degree than that conveyed through the tubes to the rooms; or where fuel is cheap, by the liquefaction of salts. Of this kind, a great number of freezing mixtures have lately been produced, and the exact constituents have been kept secret by the manufacturers; but it is probable that no more convenient combination can be employed than saltpetre and sal-ammoniac, both easily procureable in India; and, having the unusual property amongst salts of crystallising separately from the combined solution, they may be used over and over again *ad infinitum*, employing a fire if natural means are insufficient for evaporating the fluid.

We thus see that there is a natural law which we may avail ourselves of, to cool air to any extent by the employment of mechanical power; and simply in compressing air by means of a forcing pump into a closed vessel, which is a good conductor of heat, as a coil of pipe under water; the air will rise in temperature at first to a degree proportioned to the compression, say 50° Fahrenheit above whatever it was before; so that whether the atmosphere we begin operations in is 70°, or 100°, or 120° Fahrenheit in the shade, it matters not to the success of this method. The compressed air, which would thus have risen in the intermediate case from 100° to 150°, would by degrees give off that extra heat to the water surrounding the cooler (it is only necessary, it will be observed, to have a certain quantity of water of a temperature not above 100°, which in general will not be very difficult to obtain); and if the air then be allowed to escape from the pressure and confinement into the atmosphere, it will fall again 50° below 100°, or be found at 50° Fahrenheit.

If the air had been allowed to escape *immediately* after compression, its temperature would not have been altered in the final result, it would have been increased certainly on compression to 150°; but then expanding from there, the cooling effect could only bring it down to 100°. If, however, as described above, *we carry off the extra 50° by conduction and radiation during the time of the air being in the compressed state*, then it evidently must issue at the low temperature of 50° Fahrenheit; and if a sufficiently large pump is kept at work, and the cooler of the compressed air be sufficiently extensive, there is evidently no question but that of expense to prevent us from having a constant stream of any amount of air issuing from the other end of the apparatus, and cooled to any extent that may be desirable.

This I believe is the first time that this property of air has been put into requisition for any purpose of the sort, but it first occurred to me in South Africa in 1843. In 1844 I had a small apparatus made to test this matter experimentally at the Cape, and a larger one in Edinburgh in 1847; and in this way soon ascertained that the quantity of rise in the temperature of air for a small degree of compression was so great (about 30° Fahrenheit for $\frac{1}{4}$ of an atmosphere), that there could be no doubt that when a good arrangement of the machinery had been planned, and when it had begun to be manufactured on a large scale, it would be found to be abundantly within the means of most of our countrymen in India and in tropical climates.

Thus I hope that the general problem of cooling the air of rooms in tropical climates, may be considered to have been completely solved, and that by no very expensive means or complicated apparatus. And should the Society be of the same opinion, and private gentlemen be disinclined to run the risk of incurring expense for a machine which has never yet been practically tried, then I do hope that some steps may be taken to urge on the honourable East India Company or her Majesty's government, the propriety of trying the experiment in some of the large hospitals, where the plan could be so much more efficiently carried out and superintended than in a private establishment, and where so many of our countrymen may be suffering, and even dying, at this moment sheerly from the effects of too much warmth in the atmosphere.

ATLANTIC WAVES.

On Atlantic Waves, their Magnitude, Velocity, and Phenomenon. By Dr. Scoresby.

During *two* passages across the Atlantic in 1847-8, I had opportunities for investigating certain elements respecting deep sea waves more favourable than had ever before occurred within my experience in navigation. These observations, it should be noted in the outset, and the results deduced from them, were entirely uninfluenced by, and separate from theory. They form but a contribution to this interesting branch of natural phenomena; but I offer them the more readily from the circumstance of their entire independency and speciality. It was in our return voyage from America that the highest seas occurred, when the circumstances adapted for interesting observations were singularly favourable; for, whilst the magnitude and the peculiar construction of the upper works of the ship—the *Hibernia*—afforded various platforms of determinate elevation above the line of flotation for observations on the height of the waves, the direction of the ship's course, with respect to that of waves, was generally so nearly similar as to yield the most advantageous agreement or accordance for observations on their width and velocity. These observations I shall extract, in their order, from my journal kept during the homeward passage.

My first observation worth recording is under the date of March 5, 1848, when the ship was in latitude about 51°, and longitude (at noon) 38° 50′ W.—the wind then being about W.S.W., and the ship's course, true, N. 52° E. At sunset of the 4th the wind blew a *hard gale*, which, with heavy squalls, had continued during the night; so that all sail was taken in but storm-staysail forward. The barometer stood at 29·50 at 8 p.m., but fell so rapidly as to be at 28·30 by 10 the next morning. In the afternoon of this day I stood some time on the saloon deck or cuddy roof—a height, with the addition of that of the eye, of 23 feet 3 inches above the line of flotation of the ship, — watching the sublime spectacle presented by the turbulent waters. I am not aware that I ever saw the sea more terribly magnificent. I was anxious to ascertain the height of these mighty waves; but found almost every wave rising so much above the level of the eye, as indicated by the intercepting of the horizon of the sea in the direction in which they approached us, as to yield only the *minimum* elevation, and to show that the great majority of these rolling masses of water possessed a height of considerably *more* than 24 feet (including depression as well as altitude), or, reckoning from the mean level of the sea, of *more* than 12 feet. Exposed as the situation was, I then adventured to the larboard paddle-box, which was about 7 feet higher, where the level (as ascertained afterwards at Liverpool, allowance being made for the alteration in the draught of water of the ship,) was 24 feet 9 inches above the sea. This position, with 5 feet 6 inches, the height of my eye, gave an elevation altogether of 30 feet 3 inches for the level of the view then obtained,—a level, it should be remarked, which was very satisfactorily maintained during the instants of observation, because of the whole of the ship's length being occupied within the clear "*trough* of the sea," and in an even and upright position, whilst the nearest approaching wave had its maximum altitude. Here, also, I found at least *one-half* of the waves which overtook and passed the ship were far above the level of my eye. Frequently I observed long *ranges* (not acuminated peaks) extending 100 yards, perhaps, on one or both sides of the ship,—the sea then coming nearly right aft,—which rose so high above the visible horizon, as to form an angle estimated at 2 to 3 degrees (say 2½°) when the distance of the wave summit was about 100 yards from the observer. This would add near 13 feet to the level of the eye. And this measure of elevation was by no means uncommon,—occurring, I should think, at least once in half-a-dozen waves. Sometimes peaks of crossing or crests of *breaking* seas would shoot upward at least 10 or 15 feet higher. The *average wave* was, I believe, fully equal to that of my sight on the paddle-box, or more, that is, $\frac{30}{2} = 15$ feet, or upwards; and the *mean highest waves*, not including the broken crests, about 43 feet above the level of the hollow occupied at the moment by the ship. Illuminated as the general expanse not unfrequently was by the transient sunbeam breaking through the heavy masses of the storm-cloud, and contrasting its silvery light with the prevalent gloom, yielding a wild and partial glare, the mighty hills of waters rolling and foaming as they pursued us, whilst the gallant and buoyant ship—a charming "sea-boat"—rose abaft as by intelligent anticipation of their attack, as she scudded along, so that their irresistible strength and fierce momentum were harmlessly spent beneath her and on her outward sides,—the storm, falling fiercely on the scanty and almost denuded spars and steam chimney raised aloft, still indicated its vast, but as to us innoxious, power, in deafening roarings, altogether presented as grand a storm-scene as I ever witnessed, and a magnificent example of "the works of the Lord," specially exhibited to sea-going men, "and his wonders in the deep." In the afternoon of the same day the gale again increased, blowing, especially during the continuance of a much protracted hail-shower, terrifically,—roaring like thunder whilst we scudded before it, causing the ship to vibrate as by a sympathetic tremor, and the tops of rolling waves, too tardy, rapid as was their actual progress, for the speed of the assailing influence, to be carried off and borne along on the aerial wings in a perfect drift of spray! But during the period of these most vehement operations of nature, I was fortunately enabled, from familiarity with sea enterprise, to pursue my observations with entire satisfaction.

The next day—March 6—added to the interest of these investigations by developing the character of the Atlantic waves under a long and fiercely-continued influence of a little varying wind. It had blown a heavy gale, violent in the showers, from the north-westward, from Saturday evening the 4th, to the evening of Sunday, from 26 to 30 hours; during the night, too, of Sunday, it had again blown hard (abating towards the morning of Monday), and making a total continuance of the storm, in *its violence*, of about 36 hours.* I renewed my observations on the waves at 10 a.m.—the storm having been then subdued for several hours, and the height of the waves having perceptibly subsided. Soon I observed, when standing on the saloon-deck, that ten waves, in one case, came in succession, which all rose above the apparent horizon,—consequently they must have been more than 23 feet, probably the *average* might be about 26 from ridge to hollow. At this period I also found that occasionally (that is, once in about four or five minutes), three or four waves in succession, as seen from the paddle-box, rose *above* the visible horizon—hence they must, like those of the preceding day, have been 30 feet waves. But one important *difference* should be noted—viz., that they were of no *great* extent on the ridge, presenting, though more than mere conical peaks, but a moderate elongation. Another subject of consideration and investigation, on this occasion, was the period of the regular waves overtaking the ship, and the determination, proximately, of the actual width or intervals, and their velocity.—1. The ship was then going *nine* knots only, the free action of the engines being greatly interfered with by the heavy sea running, and the lines of direction of the waves and the ship's course differed about 22½ degrees, the sea being two points on the larboard quarter—in other words, the true course of the ship was east; the direction *from* whence the sea came was W.N.W.

2. The period of regular waves, in incidental series, overtaking the ship were observed as follows:—

Waves.		Min.	Sec.	Mean.
20	occupied	5	30	16·5″
10	„	2	35	15·5″
10	„	2	50	17·0″
10	„	2	45	16·5″
8	„	2	16	17·0″
			General average	16·5″

3. The length of the ship was stated to be 220 feet. The time taken by a regular wave to pass from stern to stem appeared, on a mean of several observations, to be about six seconds. Hence 6″ : 220 feet (the width passed over in that time) : : 16·5 feet to 605 feet (the width passed over betwixt crest and crest.) But this extent, by reason of the obliquity of the direction of the waves to the course of the ship, is found to be elongated about 45 feet, reducing the probable mean distance of the waves to 559 feet. Independently of this process, I had previously estimated the distance of the wave crests, ahead and astern when the ship was in the hollow, as I stood near the centre of the ship's length on the paddle-box, at 300 feet each way, by comparing the intervals betwixt my position and the place of the wave-crest, with the known length of the ship. This comparison frequently re-considered and repeated, subsequently yielded, in much accordance with the former, a total width in the line of the ship's course, of about 600 feet.

4. But the total distance betwixt the crests of waves, then reckoned at 550 feet, a distance passed by the wave in 16·5 seconds of time, by no means indicates, it is obvious, the real velocity of the wave, as the ship meanwhile was advancing nearly in the same direction at the rate of nine knots—that is, nine geographical miles, or (6075·6 feet × 9 =) 54,680·4 feet per hour, or 15·2 feet per second. During the time, therefore, of a wave passing the ship = 16·5″, the ship would have advanced on its course 16·5 × 15·2 = 250·6 feet. Reducing this for the obliquity of two points we have 231·5 feet to be added to the former measure, 559 feet, which gives 790·5 feet for the actual distance traversed by the wave in 16·5 seconds of time, being at the rate of $\left(\frac{3600'' \times 790\cdot5}{16\cdot5} = \right)$17,251·7 feet, or 32·67 English statute miles per hour. To know how far this result is but proximate, it should

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* The barometer on Saturday, at 8 p.m., was at 29·50; at 6 a.m. of Sunday it had fallen to 28·30, being 1·2 inches in 10 hours. At 6 p.m. of the latter day it had risen to 30·00 inches.

be considered that, of the several elements employed in the calculation, all but one might be deemed accurate.

The interval of time occupied by the transit of a wave with respect to the position of the ship, the *direction* of the ship's motion with relation to that of the waves, and the speed of the ship through the water, may all be recorded as essentially accurate. The element in doubt is that of the average distance from summit to summit of the waves. This distance, it has been seen, was by a twofold process of observation or comparison accordantly assumed. The value of the judgment derived from rapid comparison of measures by an eye accustomed to such estimations is, it should be observed, far higher than might be generally considered. The practical military commander or engineer officer is able to make, by mere inspection of the ground before him, remarkably close estimates of spaces and distances. When engaged in the Arctic whale fishery, I was enabled, from habit and comparison of unmeasured spaces with known magnitudes, to estimate certain distances with all but perfect accuracy. Thus, as to a circumstance in which we were most deeply interested—the near approach of a boat to a whale—I found it quite practicable, whenever the pursuing boat approached within twice or thrice its length (except when the position was near end on) to estimate the distance to less than a yard. Now, the means of comparison by the eye as to the estimation of the breadth of the Atlantic waves, was that of the ship's length of 220 feet. When the ship was fairly in the middle of the depression betwixt two waves it was assumed, with reference to this known measure, that something obviously less, but not greatly so, than the ship's length, was the distance of each of the two waves then contemplated—giving a total width of about 600 feet. But the comparison of the time required by a wave to pass from stem to stern, with the average time of transit of an entire wave, yielded a much better result; and, on much consideration of the subject, I am inclined to believe that the estimate is a tolerably close approximation to the truth. It should be observed, too, that as the headway of the ship, in the direction of the course of the wave—being a known quantity—it was favourable to the accuracy of the estimate. For, assuming an error in the width of the waves to have occurred, say to the amount of one-twelfth of the whole, or 49 feet—the effect upon the calculated velocity of the wave would have been only about a sixteenth, or 2·16 miles per hour.

The form and character of these deep-sea waves became at the same time interesting subjects of observation and consideration. In respect to form, we have perpetual modifications and varieties, from the circumstance of the inequality of operation of the *power* by which the waves are formed. Were the wind perfectly uniform in direction and force, and of sufficient continuance, we might have in wide and deep seas waves of perfectly regular formation. But no such equality in the wind ever exists. It is perpetually changing its direction within certain limits, and its force too, both in the same place and in proximate quarters. Innumerable disturbing influences are therefore in operation generating the varieties more or less observable in natural sea waves.

In regard to my own observations of the actual forms of waves, nothing particularly new could be expected from an inquiry of this kind in regard to phenomena falling within the perpetual observation of seagoing persons; yet, at the risk of stating what might be deemed common, I will venture to transcribe from my notes made with the phenomena before me, the leading characteristics which engaged my attention. During the height of the gale (March 6th) the *form* of the waves was less regular than after the wind had, for some time, begun to subside. Though in many cases when the sea was highest the succession of the primary waves was perfectly distinct, it was rather difficult to trace an identical ridge for more than a quarter to a third of a mile. The grand elevation in such case sometimes extended by a straight ridge, or was sometimes bent as of a crescent form, with the central mass of water higher than the rest, and, not unfrequently, with two or three semi-elliptical mounds in diminishing series, on either side of the highest peak. These principal waves, too, it should be noted, were not continuously regular, but had embodied in their general mass many minor, secondary, and inferior waves. Neither did the great waves go very prevalently in long parallel series like those retarded by shallow water on approaching the shore; but every now and then changed into a bent cuneiform crest with breaking acuminating peaks. On the following morning (March 7), after a second stormy night, wind S.S.W. (fine), we had a heavy and somewhat cross sea (from the change of wind from W.S.W. to S.S.W). But the almost unabated magnitude of the more westerly waves indicated a continuance of the original wind at some distance astern of us. The gale had moderated at daylight, and the weather became fine; but as the sea still kept high, its undulations became more obvious and easily analysed. At three in the afternoon, when about a third part of the greater undulations averaged about 24 feet from crest to hollow, in height, these higher waves could be traced right and left as they approached the ship to the extent of a quarter of a mile on an average, more or less. Traced through their extent the ridge was an irregular roundbacked hill, precipitous often on the leeward side of waters. The undulations, indeed, as to primary waves, consisted mainly of these roundbacked masses, broken into or modified by innumerable secondary and smaller waves within their general body. The time in which these waves passed the ship was now, on an average, about 15 seconds, the ship's speed being increased from 9 to 11 knots, and the obliquity of the ship's course to the direction pursued by the waves was 3 points. On the 9th, two days after the above condition of the waves—whilst the sea yet ran high—few waves could be traced continuously above 300 or 400 yards in extent along the same ridge. The crests often curled over, but none so as to reach the height of a 30-feet wave, and broke for a wide space, estimated at 50 to 100 yards in continuity.

Miscellaneous Notes and Suggestions.—The mode adopted in these researches of finding the *height* of wave is, I believe, quite satisfactory, and, observed with care and with relation to numbers or proportion of waves, as accurate as need be. The depression of the horizon in respect to the elevation of the observer is too small to form even a correction. As the horizon from the paddle-box $\psi = 15$ feet, had only a depression of 3′ 49″, the distance of the visible horizon, as seen from this elevation, would be 4·45 statute miles, and the actual depression in feet due to the distance of the summit of the wave when the ship was in the midst of the hollow, could only be 0·18 foot or 2·16 inches. Other modes of determining the width of a wave—or the extent betwixt summit and summit—much preferable to that described (the only available one I could devise) might easily be adopted where the management of the ship was in the hands of the observer. In steam ships the simplest mode for high seas, perhaps, would be, altering the speed of the ship when going in the direction of the wave or against the wave; the ratios of the times of transit of wave-crests, under different rates of sailing of the ship might yield results very close to the truth. In moderate-sized waves the plan adopted by Capt. Stanley—whose observations I met with before this meeting—seem satisfactory. But in calms, or moderate weather after a storm—that is, for the determination of the velocities of less elevated waves—a variety of processes might be available.

Mr. John Scott Russell observed that there were great doubts as to the actual heights of waves. It was now beyond a doubt that we had waves 24 feet, 30 feet, and 43 feet high, and with the swelling crest even exceeding 45 feet high. From the observations which he had conducted many years since, he had ventured to draw up a table predicting the velocities of sea waves up to even 1000 feet from trough to crest in length. Although the apparatus which he had used did not enable him to experiment on waves which exceeded 16 inches in length, yet from these pigmy waves it was most interesting to see how accurately the law was obtained; for in his table the velocity of a wave whose length was 559 feet was set down at 30 or 31 miles per hour. Dr. Scoresby's actually-observed velocity for a wave 559 feet in length was 32 miles and a fraction.

SHIP BUILDING ON THE WAVE PRINCIPLE.

The following communication from Mr. Dodgson, of the Ponta de Aréa Iron Works and Dockyard, Rio de Janeiro, to Mr. John Scott Russell, was read:—

Sir—Having been called upon late in the year 1846 to undertake the management of the above establishment (then lately organised), my attention in the ship-building department was more particularly directed to the scientific and elegant system of construction advocated by you, of which I had some information from reports in the *Civil Engineer and Architect's Journal.* Not being fortunate enough, however, to obtain any information from England respecting the "wave principle," but convinced in my own mind of the correctness of the few leading features which I had thus been enabled to collect, I determined to attempt carrying them out in two small steamers, and two brig schooners (of 240 tons) then about to be laid down (October, 1847). This I was prevented doing to the full extent on that occasion, by the opposition of the parties for whom these vessels were building, supported by the very decided opinions of all my colleagues, the resident engineer and shipwrights; the result, however, of the approximation which I was enabled to effect, was so far satisfactory that of the two steamers (propeller by sister engines), the larger of the two on these lines proved much superior, both in speed, stability, and in fact in every quality of a good passenger-boat, to the smaller lines of which, for the sake of a fair trial of system, I accepted from the Government Naval Architect, giving my vessel purposely larger dimensions, both as to length and breadth, the vessels being destined for the Bay, the direct resistance of the immersed midship sections being, however, the same in each; the advantage gained in speed was as 7 to 8, and this superiority is since maintained: the sailing vessels also gave satisfaction, being reported, after trial at sea, as very "superior sea boats," "stiff," and remarkably easy under sail, neither pitching or 'scending in heavy seas, although not very remarkable for "speed," (this quality having been since obtained by alteration of masts and sails.)

Encouraged by these results and having in the interim obtained a copy of Mr. Fishbourne's very interesting Lectures upon the subject, I proceeded in May 1848, still in the face of great opposition, to lay down the keel of a small schooner of 123 tons, following in this design the proportions recommended by Fishbourne. The result was most satisfactory, being reported, after a four months' voyage to different ports, to possess all the properties of an excellent sea boat — speed, weatherly qualities, sufficient hydrostatic stability, and great hydrodynamic (both longitudinal and lateral) stability. The master expressing himself in the highest terms of her performance, after paying proper attention to ballasting and rigging, which was not done on leaving this port. The result has been an order, for the government, of a similar vessel, for a "guarda costa." About the same time I launched a steam tug of 230 tons, and 90-horse power, destined for the heavy rolling bar of Rio Grande; her lines were also assimilated as much as such service would justify to the proportions recommended. She has now been for some months on that dangerous station, giving great satisfaction, having also made the shortest passage on record to her place of destination, and having proved herself on her trials here equal in speed to the largest steamboats of our packet company.

I have lately launched the "guarda costa" (not yet tried), and a small armed steamer, also for government (for river service and drawing 42 inches of water), both built on wave principles, and of which I take the liberty of enclosing the lines, as also of the schooner, and a small steamboat for the use of the establishment. The government steamer has just been tried, and I flatter myself will settle the question here "as to lines," her performance being most satisfactory, overcoming the "resistances," imperceptibly dividing and leaving the water almost without a ripple (at 10 knots), with very little power (two engines of 20-horse power, of Miller's). My colleagues, however, are not yet convinced of the advantages of the "full water line, aft," insisting that the sharp line would have still improved her. I must confess, myself, however, of your opinion, and I consider this as one of the most scientific and valuable points of the theory.

I am now engaged with two large steamers for government, one of 450 tons well forward; the other of 560 tons, also laid down: but as I have not been able to overcome the mistaken desire to place very heavy artillery on the forecastles, I have been obliged to adopt a rather fuller entrance line than I should have wished, approaching more to the wedge shape. Time however is required, I find, even in England, to overcome prejudices, so that we cannot expect otherwise in these countries, where the sciences and arts are in the hands of empirics, with a very few honourble exceptions, and where we have not only prejudice but envious and interested motives to combat.

I should now crave your indulgence for occupying your attention with these particulars; but I am persuaded that as the advancement of science must be an object of interest to you, its progress in this remote quarter will not be a matter of indifference as respects the system of rather the relative proportions. I should wish to offer to your consideration a few remarks, but cannot allow myself this liberty until I have the pleasure of knowing that such observations may not be considered presuming from a person who has not the advantage of your acquaintance, but whose object is also the development and progress of the arts, and whose attention has been long directed, and is now chiefly devoted to the subject of naval architecture. This being also his only excuse for the liberty of addressing you.

That the advantages which must certainly attend the introduction of the system may be attributed in this country to their original proposer and distinguished advocate, I have further taken the liberty of directing your name to be given and carved upon the stern-sheets of a large passenger boat (lattern rigged) also built here on your principles, and now plying on our magnificent Bar, bearing away the palm from all competitors.

I am, &c.

THOMAS BUTLER DODGSON,
Naval Architect.

On the Dynamic Equivalent of Current Electricity, and on a fixed scale for Electromotive Force in Galvanometry. By Mr. W. PETRIE.

The dynamic value of a current of voltaic electricity is represented by the product of the rate at which electro-chemical action is taking place at any cross section of the current, (in other words, the quantity of the current,) and the electromotive force with which the current is sustained, which may be briefly termed its energy or intensity, (provided the idea of quantity be kept distinct from this.) The first object was to secure such units of comparison for both these elements as should be at all times recoverable. This is given in respect of quantity by the rate of chemical action, and the atomic weights. In respect of intensity of the current, we have no such fixed data, and the intensity of most voltaic arrangements cannot be relied on as constants for comparison. But the elements of Daniells' Battery, and those of nitric acid batteries with negative surface of platinum, carbon, or cast-iron, give an electromotive force or intensity that can be recovered with considerable exactitude, if uniformity of circumstances, materials, &c. be tolerably attended to: these, therefore, may be used to give a fixed and recoverable point in a galvanometric scale of intensity. Now it so happens, that if we assume the degrees of the scale to be of such a size that the intensity of Daniell's (standard) elements shall be 60 of the degrees, temperature being 70 Fahr.—that of nitric acid batteries will be from 100 to 112 of the same degrees; the author, therefore, has always used this scale, to which all other voltaic arrangements can be referred. Which scale, he would suggest, would be most conveniently used in assigning the electromotive power of electric currents from any source. The mean result of careful experiments, tried directly and conversely, is that a voltaic current of one unit in quantity, (or that from one grain of zinc electro-oxidized per minute,) and of 100 degrees intensity, represents a dynamic force of 302½ pounds raised one foot high per minute. This datum is of great interest as a scientific truth in connection with the other correlative agents of nature, (heat, electricity, light, and chemical affinities, neuralgic power, &c.,) most of which we may hope soon to see reduced to a mutually comparable relation to each other, in terms of the great centre and medium of comparison, mechanical force.

On the Chemical Composition of the Rocks of the Coal Formation. By Mr. HENRY TAYLOR.

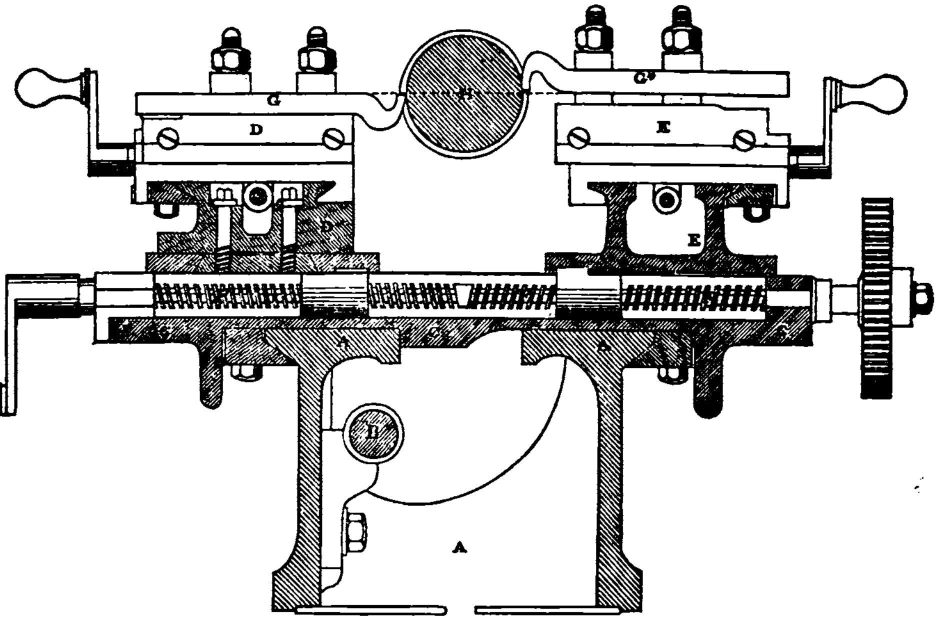
Mr. TAYLOR pointed out the analogies of constitution between certain rocks, and referred to experiments made by him on organic and inorganic constituents. The author had in view the solution of the difficult problems connected with geology, by facts deduced from chemistry; for instance, the deposition of the stratified rocks as to their order, &c., by a process of reasoning based on the composition of these rocks, and to this end he submitted several analyses as a small contribution to our knowledge of the rocks of the coal formation. Details of the analyses of fire-clay, specific gravity 2·519, good coal, specific gravity 1·259, coarse coal, specific gravity 1·269, bituminous shale, specific gravity 1·860, blue shale (slate-clay), specific gravity 2·535, micaceous sandstone, specific gravity 2·598, muscle bind, specific gravity 2 592, and of cannel coal, specific gravity 1·319, were given, and a comparative view of the analyses seemed to suggest a pretty close connection between various members of the group, taken principally from "Buddle's Hartley" colliery in the Newcastle coal field. The organic matter intermixed with the various strata enclosing the coal appeared to be of the same composition as the coal itself, except that its decomposition had been carried further. The inorganic matter of these strata likewise evidence a close connection among them, though owing to the greater number of constituents, this could not be so readily shown. Formulæ for the two classes of matter were given, and Mr. Taylor, in conclusion, hoped that the results of his analyses were sufficiently interesting to lead others into the same field of inquiry, and eventually to a right appreciation of the laws which regulate the deposition of the stratified rocks.

Notice of the Working of the New Integrating Anemometer during the past year. By Mr. FOLLET OSLER.

A sheet of *plain paper* placed in the instrument under a registering pencil is moved forward by rotating hemispherical fans, at the rate of one inch for every ten miles of air that passes; this same pencil, having a lateral motion given to it by a vane, records the point of the compass from which the wind blows, and a clock hammer descending every hour strikes its mark on the margin of the paper to express the time. Thus, in a *single line* are given, firstly, the length of the current; secondly, the direction of it; and thirdly, the time occupied in passing a given station marked hourly or at any shorter interval that may be desired.

WHITWORTH'S PATENT DUPLEX LATHE.

A paper was read from Mr. Whitworth, describing his new lathe. It is equally applicable for cylindrical or surface turning, or for cutting screws. The tools are shown as applied to cylindrical turning or screw cutting. For surface turning they would be placed at right angles to the position shown, and a self-acting motion given to the right and left hand screw. The top slide-rests are both provided with compound slides, whereby each tool may be adjusted to the work independently; and when once adjusted, the right and left hand screw only is used. Not only is double the work performed in the same time, but in long objects with a less expenditure of power, owing to the saving by the lessened pressure against the stay. The work done is of a superior kind, there being a perfect balance of forces, and consequently less vibration; and from the increased duration of the tools, only one-half the amount of error takes place. Messrs. Whitworth have five of these lathes in use in their establishment, and the work produced by them is of better quality and at half the cost it was formerly from the single lathe.



The annexed engraving is a transverse section of the lathe. A, is the bed; B, the guide screw; C, the bottom slide-rest or carriage; D, a compound top slide-rest in front of the lathe; E, a second compound top slide-rest at the back of the lathe; F, a right and left-hand screw for moving the two top slide-rests simultaneously to or from the centre of the lathe; G, G*, represent the two tools, namely, one in front and the other at the back of the lathe; H, represents a shaft under the operation of cutting.

(*The remainder of the Papers read at the British Association will be given next month.*)

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM JULY 25, TO AUGUST 22, 1850.

Six Months allowed for Enrolment, unless otherwise expressed.

Rodolphe Helbranner, of Regent-street, Middlesex, for improvements in preventing the external air, and dust, and noise, from entering apartments.—July 31.

Thomas Dickason Rotch, of Drumlamford House, Ayr, N. B., Esq., for an improved mode of manufacturing soap.—July 31.

Matthew Trattles, of Rochester, Kent, tool maker, for certain improvements in saw-sets, mallets, and other tools, and in apparatus and machinery for manufacturing the same.—July 31.

John Sheafe Gaskin, jun., of Barbadoes, West Indies, gentleman, for improvements in the manufacture of rum. To extend to the colonies only. (A communication.)—July 31.

Richard Archibald Brooman, of the firm of J. C. Robertson and Co., of 166, Fleet-street, London, Patent agents, for an improvement or improvements in abdominal supporters. (A communication.)—July 31.

James White, of Holborn, Middlesex, mill-maker, for improvements in machinery for bruising, crushing, and for expressing juice from certain vegetable substances.—July 31.

Henry Bessemer, of Baxter House, St. Pancras-road, Middlesex, engineer, for certain improvements in apparatus acting by centrifugal force, in the manufacture of sugar, and other improvements in the treatment of saccharine matter by such apparatus.—July 31.

Juan Nepomuceno Adorno, of Golden-square, Middlesex, gentleman, for improvements in manufacturing cigars and other similar articles.—July 31.

Henry Rishton, of Kendal, Westmoreland, plumber, for certain improvements in water-closets and urinals.—July 31.

Joseph Poole Pirsson, civil engineer, New York, America, for certain improvements in steam machinery and apparatus connected therewith.—July 31.

John Hynam, of Prince's-square, Finsbury, Middlesex, chemical-light manufacturer, for improvements in machinery for placing splints of wood, and wax, and composition tapers, in frames for dipping.—July 31.

John James Greenough, of George-street, Hanover-square, gentleman, for improvements in obtaining and applying motive power.—July 31.

Peter Fairbairn, of Leeds, York, machinist, and John Hetherington, of Manchester, for certain improvements in machinery or apparatus for preparing, spinning, and weaving cotton, flax, and other fibrous substances; also in constructing and applying models or patterns for moulding, preparatory to casting parts of machinery employed in preparing, spinning, and manufacturing fibrous substances; and also in certain tools to be used in making such machinery.—July 31.

Matthew Gray, of Morris-place, Glasgow, practical engineer, for an improved method of supplying steam-boilers with water.—July 31.

Edouard Gabriel Leroy, of Paris, France, gentleman, for certain improvements in locomotive engines, and in the means and apparatus to be employed for generating and condensing the steam to be used therein.—July 31.

Joseph Shaw, of Paddock, Huddersfield, York, cloth finisher, for improvements in constructing and working certain parts of railways.—August 3.

John Gwynne, of Lansdowne-lodge, Notting-hill, merchant, for improvements in obtaining motive power, and in applying the same to giving motion to machinery. (A communication.)—August 5.

Francis Kane, of Berner's-mews, Middlesex, chair maker, for improvements in reclining chairs, in castors for chairs and other articles of furniture, and improvements in presses.—August 5.

William Crosskill, of Beverley, York, civil engineer, for improvements in mills for grinding, splitting, pulverising, and crushing grain, bones, bark, ore, and other hard substances, and for grinding paint and other soft substances, and for shelling or removing the skin from rice and other grain, and in machinery for giving rotary motion to mills, thrashing machines, and any other machine requiring rotary motion to be communicated by any horse or other animal. (A communication.)—August 6.

Joseph Steele, of Chancery-lane, for improvements in coating and impregnating metals and metallic articles. (A communication.)—August 9.

Henry Meyer, of the Strand, Middlesex, gentleman, for certain improvements in power looms for weaving.—August 10.

Selim Richard St. Clair Massiah, of Aldermen's-walk, New Broad-street, London, for improvements in the manufacture of artificial marble and stone, and in treating marble and stone.—August 10.

Alfred Holl, of Greenwich, Kent, engineer, for improvements in steam-engines.—August 12.

Armand Nicolas Fréche, merchant, residing in Paris, for improvements in obtaining power.—August 12.

Charles Cadby, of Liquorpond-street, Middlesex, pianoforte-maker, for improvements in stringed musical instruments.—August 12.

George Thompson, of Park-road, Regent's-park, Middlesex, gentleman, for certain improvements in machinery and apparatus for cutting, digging, or turning up earth, applicable to agricultural purposes.—August 12.

Samuel John Pittar, of Church-place, Clapham, Surrey, civil engineer, for certain improvements in umbrellas, and parasols.—August 13.

Peter Claussen, of Great Charlotte-street, Blackfriars, Surrey, manufacturer, for certain improvements in bleaching, and in the preparation of materials for spinning and felting, and in yarns and felts. (A communication.)—August 16.

William Keates, of Liverpool, merchant, for improvements in machinery for manufacturing rollers and cylinders used for calico printing, and other purposes. August 16.

Charles Heard Wild, of St. Martin's-lane, Middlesex, civil engineer, for improvements in certain structures for retaining water.—August 17.

Henry Holland, of Birmingham, umbrella furniture manufacturer, for improvements in the manufacture of umbrellas and parasols.—August 22.

Edmé Augustin Chameroy, of Paris, for improvements in paving streets and other surfaces.—August 2

Frederick Hale Thomson, of Berner's-street, Middlesex, gentleman, and Thomas Robert Mellish, of Portland-street, Middlesex, glass-cutter, for improvements in cutting, staining, silvering, and fixing articles of glass.—August 22.

LECTURES ON THE HISTORY OF ARCHITECTURE,

By Samuel Clegg, Jun., M.I.C.E., F.G.S.

Delivered at the College for General Practical Science, Putney, Surrey.

(PRESIDENT, HIS GRACE THE DUKE OF BUCCLEUCH, K.G.)

Lecture IX.—ROME.

The Five Orders—Masonry—Temples—Sepulchres.

Having already described Rome as it existed under Etruscan domination or influence, it is needless to revert to its early history. After the expulsion of the Kings, the stern republican spirit that prevailed caused the Romans to neglect the fine arts as tending to enervation and a love of luxury: a nation of warriors, their sole aim was to increase the territory and power of Rome. That the buildings of republican Rome, however, were thought worthy of attention, is proved by the appointment of ædiles or magistrates, who had the care of their preservation, an office first created in the 206th year of Rome: but they were for the most part simple and unadorned. The solid and plain Tuscan order satisfied the taste of the people; nor did they seek for farther embellishment.

The materials within the power of the Romans in the time of the commonwealth were by no means favourable to decorative architecture; the dark peperino, the tufa of the Campagna, and the porous travertine, could not vie with the marbles of Greece and Asia; and Rome was not yet enriched with foreign spoils.

In the time of Camillus, who died 365 B.C., Rome was reduced to ashes; and the rude cottages of the city of Romulus were afterwards replaced by buildings of a more solid and convenient description. But a still greater change took place on the conquest of Greece and Sicily. Horace says, "Greece, when subdued, captivated the fierce conqueror, and brought the arts into rustic Latium."

Notwithstanding the persuasive influence of beauty, the old simple habits did not at once give way, and Cato still railed against the importation of statues and paintings as the introduction of so many enemies to Rome. But when a more refined and cultivated taste once made good its entrance, no censor could long stay its progress, and soon the victorious generals emulated each other in despoiling the conquered provinces for the adornment of their native cities. Metellus Macedonicus is said to have been the first to build a marble temple in Rome: he also erected a portico, in which he placed twenty-five equestrian statues, brought from Macedonia. His contemporary, Lucius Mummius, also brought rich spoils from Corinth; but betrayed his ignorance of what he had acquired, by threatening that those who had charge of the transport of the splendid statues and paintings, should be made to replace any that were lost or injured. At the triumph of Paulus Æmilius, on his return from Greece and Macedonia, 250 chariots were barely sufficient to carry the works of art brought in his train. When we consider that these continued to be accumulated year after year, we read without surprise that the number of statues in Rome formed another population.

The first mention we find of the quarries of Luna or Carrara, is in the time of Julius Cæsar. The prefect of Cæsar's army in Gaul caused his house to be lined with this beautiful material, and every column to be sculptured in solid Carrara or Carystian marble. In a few years the residences of the Roman patricians vied with those of the eastern potentates in magnificence. Rich marbles were brought at an enormous expense from Greece, Asia, and Egypt. Where these could not be afforded, painted imitations were substituted, or inferior marbles were stained to represent those of a more costly description.

In the time of Augustus Cæsar, a second conflagration devastated the city; after which it was restored with increased splendour, giving rise to the saying of Augustus, that he had found Rome of brick, and left it of marble. The architects and artists of Greece flocked to imperial Rome, where they were sure of finding patronage and employment, and principally under their superintendence were erected the temples of Mars Ultor, Jupiter Tonans, Apollo Palatine, and others, besides the theatre of Marcellus, and several porticoes, public libraries and other buildings. The celebrated Vitruvius (better known by his writings than by his architectural works) belongs to this period. His treatise on architecture is the only book on the subject remaining to us from the classical age. The example of Augustus was followed by his successors, who emulated each other in the embellishment, not only of Rome, but also of the provincial cities. Another and most disastrous conflagration occurred in the reign of Nero, when fourteen quarters or districts of the city were utterly destroyed. Rumour pointed to the emperor himself, as the wilful author of this calamity. Ruffians were seen while the fire was raging rushing about with lighted torches, throwing them where most like to ignite the surrounding materials, and preventing the wretched populace from attempting to extinguish the flames. Nero, to remove the odium of the deed from himself, accused the Christians, who were consequently made to suffer unheard-of tortures. Many valuable specimens of Greek art were lost in this fire, but a great improvement was apparent when the city was rebuilt, in the increased regularity and width of the streets, and greater commodiousness of the houses. Magnificent, however, as were the restorations of Nero, art could not be expected to flourish in its pristine purity under a patron who gilded some of the statues and cut off the heads of others, in order to substitute his own.

During the reigns of Trajan, Hadrian, and the Antonines, Rome still continued to increase in opulence and splendour; it was indebted to Trajan for some of its noblest monuments, erected by the architect Apollodorus. The Emperor Hadrian was an architect himself, and a great builder. Many structures were erected by him in Italy and the provinces of the empire; and in several places whole cities arose at his command, as at Athens and Jerusalem. Unfortunately, vanity and cruelty were united with taste and magnificence in the mind of this emperor. He was accustomed to employ an architect of the name of Detrianus to execute his designs, who was too good a courtier to criticise; but wishing for the approval of the more celebrated Apollodorus, Hadrian submitted to this great artist a plan for a Temple of Venus: the too candid Apollodorus dared to laugh at the design, saying that if the statues seated there were inclined to get up, they would knock their heads against the disproportionately low ceiling. This censure cost the unfortunate architect his life. He was put to death by order of his offended master.

From the time of the Emperor Decius (250 A.D.) Rome rapidly declined. Incessant wars drained the revenue, and required the presence of the emperor abroad. Under Dioclesian, the seat of government was removed to Nicomedia, on the sea of Marmora; and to Milan, where Maximian held his court; and in 330 A.D., the final blow was given to ancient Rome by the foundation of the new capital of Constantine the Great.

Gibbon quotes the following passage from the writings of Poggius, who described Rome in 1430, A.D.:—"Her primeval state, such as she might appear in a remote age, when Evander entertained the stranger of Troy, has been delineated by the fancy of Virgil. This Tarpeian rock was then a savage and solitary thicket. In the time of the poet, it was crowned with the golden roofs of a temple: the temple is overthrown, the gold has been pillaged, the wheel of fortune has accomplished her revolution, and the sacred ground is again disfigured with thorns and brambles. The hill of the Capitol on which we sit was formerly the head of the Roman empire; the citadel of the earth; the terror of kings; illustrated by the footsteps of so many triumphs, enriched with the spoils and tributes of so many nations. This spectacle of the world, how is it fallen?—how changed?—how defaced?—the path of victory is obliterated by vines, and the benches of the senators are concealed by a dunghill. Cast your eyes on the Palatine hill, and seek among the shapeless and enormous fragments, the marble theatre, the obelisks, the colossal statues, the porticoes of Nero's palace. Survey the other hills of the city: the vacant space is interrupted only by ruins and gardens. The forum of the Roman people, where they assembled to enact their laws and elect their magistrates, is now enclosed for the cultivation of pot-herbs, or thrown open for the reception of swine and buffaloes. The public and private edifices that were founded for eternity lie prostrate, naked, and broken, like the limbs of a mighty giant; and the ruin is the more visible, from the stupendous relics that have survived the injuries of time and fortune."

Notwithstanding many new architectural features, the offspring of new wants, the Romans were far from being an inventive people; they were indebted for their peculiar style to the united influence of Greece and Etruria: from the former they received the Orders, from the latter the arch and the knowledge of vaulting. In Roman architecture we find five orders; the Tuscan, Doric, Ionic, Corinthian, and Composite. The Tuscan order appears to have fallen into disuse after the time of the Commonwealth, for though described at length by Vitruvius, scarcely an ancient example remains. The Greek-Doric was superseded by the Roman, of a more light and ornamental character; the height of the column was increased from four or five to eight, or eight and a half diameters; the shaft was finished by an astragal and fillet; the hypotrachelium or necking between this and the ovolo was frequently ornamented with roses or other devices; to the abacus is added an ogee and fillet round the upper edge, and the shaft is generally plain. Fine specimens of the Roman Doric are to be seen in the theatre of Marcellus and the amphitheatre at Nismes; most of the examples of this order have the attic base. The frieze, instead of being finished by triglyphs at the angles, according to the Greek method, was generally terminated by a half metope; the metopæ were seldom so richly sculptured as in the Greek order, a simple patera or wreath, or ox-skull adorned with festoons, was repeated in each, or alternated. The dentil was sometimes introduced in the cornice instead of the mutule, and the face of the entablature was perpendicular with the upper diameter of the column. The Doric order was seldom used, except where the building was to rise to the height of two or more stories, when the Doric was placed as the lowest order; in the amphitheatre at Nismes, both stories are Doric. The Ionic order is, comparatively with the Corinthian and Composite, rarely met with, and is in most instances a mere copy from the Greek; the Temple of Concord, however, is a singular exception, in this the capitals have the form of the upper part of the Composite, with small angular volutes, a cable ornament, and enriched cyma, torus, and fillet below. Amongst the numerous fragments discovered in Italy is an Ionic capital, the volutes of which are an exact representation of the horns of a ram, greatly strengthening the supposition of such having been their origin. The most beautiful example of the Ionic order in Rome is the Temple of Fortuna Virilis,* supposed to have been erected by a Greek architect. There is a difference of opinion as to whether the Corinthian or Composite should be placed first; but as both Palladio and Vignola give precedence to the Corinthian, I cannot greatly err in following their example. The Corinthian became the favourite order in Imperial Rome, and was repeated (though with great variety of detail) so endlessly that the eye becomes wearied with excess of magnificence. We undoubtedly owe our most finished examples of this order to the Romans; amongst which, for beauty and elegance of design, the exquisite columns of Jupiter Stator * stand unrivalled. Only three columns with their entablature remain standing, the whole composed of the finest white marble. The columns are ten diameters in height, the shafts diminish nearly $\frac{1}{7}$th, and have twenty-four flutings; in the capital, the second row of leaves are lower than in the rule given by Vitruvius, leaving more room for the sweep of the cauliculi and scrolls; the intertwining tendrils in the centre have a particularly light and graceful effect; the cornice is high; one modillion is placed over each column and three in the interval; the modillions are peculiar in having the volutes of equal size. In the Temple of Vesta at Tivoli,* the second row of leaves are still lower than in the former example; the scrolls rise without cauliculi, and are so large as almost to approach those of the Composite order; behind the second row of acanthus is a small row of water leaves, the tops of which touch the bottom of the scrolls.

It is worthy of observation, that while in the pure Greek-Corinthian, either the wild or cultivated acanthus was always closely imitated, in the Roman the foliage generally took the form of the olive leaf, though with the growth of the acanthus; this may be seen in the capitals of Jupiter Stator, Mars Ultor, and many others. The following examples will show the varied proportions of columns of the Corinthian order:

	Lower Diameter.		Height.	
	ft.	in.	ft.	in.
Temple of Antoninus and Faustina ……	4	$6\frac{7}{12}$ ……	43	3
Temple of Jupiter Stator ……………	4	$5\frac{3}{8}$ ……	45	$3\frac{7}{12}$
Basilica of Antoninus or Temple of Mars	4	$6\frac{1}{2}$ ……	45	$5\frac{1}{2}$
Temple of Mars Ultor ……………	6	0 ……	58	0

The proportions of the entablature vary in different examples from one-fifth of the height of the column to one-fourth or more. In the Temple of Antoninus and Faustina, the cornice has neither dentils nor modillions, but the frieze is enriched with figures of griffins, candelabra, and scrolls. The Arch of Titus has been said to be the earliest example of the Composite order, but this appears to be a mistake, as this order is seen in the atrium of the house of Pansa in Pompeii, which was destroyed several years before the Arch of Titus was erected. Some authors deny the claim of the Composite to be described as a separate order, and consider it merely as a variation of the Corinthian, but as it has several distinctive features, it saves confusion to allow it to retain its place as a fifth order. The capital is formed by a union of the Ionic and Corinthian; it is somewhat deeper in proportion than the latter, and like it is divided into three parts; the first occupied by the angular volutes, with the intervening torus and astragal; the second by the upper, and the third by the lower range of acanthus leaves; the fillet below the astragal forms the lip of the vase. This is the usual form, but the Romans frequently varied it, and sometimes with great elegance and propriety. In some instances, the centre flower of the abacus is replaced by the figure of an eagle, as in the Portico of Septimus; in others, the eagles occupy the place of the volutes at the angles, with Jupiter's thunderbolts in the centre; in other examples, ox-skulls are placed at the angles, with a festoon between, the lower part of the capital being finished with a row of water leaves, and so on in infinite variety. The shafts too were either plain or capriciously ornamented, some with spiral flutings, as in the Baths of Dioclesian, and others with wreaths of leaves, as in the Temple at Spoleto in Ombria; the flutings were frequently filled in with cablings part of their height, as in the Baths of Nismes, where the shaft springs from a row of acanthus leaves above the base. These fancies were not confined to the Composite, but sometimes extended to the Corinthian; the attic base was applied to both orders. The entablature of the Composite resembled that of either the Ionic or Corinthian, but did not follow any positive rule. The mouldings in Roman architecture differ considerably from the Greek, and seldom present so graceful a profile; they are rounder and more prominent, and the enrichments are bolder and more profuse. The frieze in both the Corinthian and Composite orders is frequently swelled or rounded. The usual intercolumniation of the temples and porticoes was pycnostyle or 1½ diameters, contrary to the recommendation of Vitruvius, who condemned both the pycnostyle and systyle as too narrow. "Neither of these species," he says, "ought to be generally adopted, for the matrons who go to their supplications mutually supporting each other, cannot pass through the intercolumniations unless they separate and walk in files." He alludes also to the obstruction caused to the view of the entrance; but this was obviated by making the centre intercolumniation of greater width than the others.

Contrary to the usual practice of the Greeks, the Roman pilaster capitals repeated those of the orders; in some instances the pilaster tapered upwards in the same degree as the column. The greatest distinctive feature in Roman architecture, however, was the introduction of the arch. It is almost impossible to imagine that the Greeks, having constant intercourse with both Egypt and Etruria, should have been ignorant of its mode of construction: it is a more probable conclusion, that they felt the want of harmony between the horizontal lines of the stylobate and entablature and the semicircular form; and having no occasion to roof in any large area (their great temples being hypæthral) they rejected the arch from choice rather than from want of knowledge. The vast multitudes that flocked to Rome rendered it necessary to erect public buildings of much greater magnitude than had been required in any of the cities of Greece; besides which, the humidity of the climate rendered a covering more desirable: thus the principle of vaulting was brought into use, as any space that could be spanned by a beam of wood or block of stone would have been inadequate to the wants of the population. The use of the arch naturally produced great changes; where introduced, the walls became the principal support of the roof, and the columns being merely ornamental accessories, were slighter, and further apart. At first the arch was entirely independent of the order, springing from imposts behind the column, and not reaching so high as the entablature. The imposts and archivolts had only a few simple mouldings, but the key-stone was frequently sculptured with a head or mask, or ornamental console. In the time of Hadrian the imposts were made in the form of pilasters, or the arch sprung from the architrave above the columns; thus breaking the frieze and cornice, and destroying the horizontal line hitherto so strictly preserved. To this succeeded arches rising immediately from the capital of the column, the entablature being altogether omitted, as in the Emperor Dioclesian's palace at Spalatro, thus gradually leading to the Romanesque or early Christian style. The Roman arch was always semicircular, with plain wedge-shaped voussoirs of stone or brick, sometimes of stone and brick alternately. Vaulting came into use in Rome at the same time as the arch; the earliest kind was that called the Barrel or Wagon Vault, presenting a uniform concave surface throughout its length. Groining was also practised by the Romans, and formed by the intersection of vaults crossing at right angles. That domical vaulting was thoroughly understood we have a proof in the Pantheon. Another new feature was the pedestal as applied to architecture; this may be ascribed to two causes—the numerous wrought-marble columns brought from

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* See Taylor and Cresy's Rome.

Greece and Asia Minor were too short for the places they were to occupy in the buildings of Rome; it was necessary, therefore, to give them additional height; this was sometimes done by adding a moulding between the base and the shaft, but generally by raising them on a pedestal. Secondly, the width given to the arcade required the order to be of a proportionate height, so that it must have been so massive as to have been out of character with the rest of the building, or the column must have been so slender in proportion to its height as to destroy its beauty. To avoid either of these defects the pedestal was employed, by which means the proper proportion of the order was retained. The height of the pedestal was regulated either by that of the column, or by the width of the arch. The roofs of the Romans were somewhat higher in pitch than those of the Greeks, the pediments were consequently slightly more elevated. Towards the decline of the empire, semicircular pediments were introduced, though they were mostly confined to niches, or interior decoration. At Nismes, and at Baalbec and Palmyra, there are rows of niches in which semicircular and angular pediments alternate; here also are seen broken pediments, coupled columns, and other features unknown in the early times of classical architecture.

The Romans were never surpassed in any age, or by any people, in constructive skill. Brick-making was carried by them to great perfection; bricks were made of various forms, and of various sizes, from 8 inches square to 1 ft. 5 in. by 1 foot. A light kind was manufactured for vaulting, so light (according to some accounts), that they would float on water; these were much prized. The Romans employed several kinds or masonry, as the *opus incertum*, composed of stones of irregular shape and size; the *opus reticulatum*, formed with square stones laid diagonally; and the *emplectum*, the same with the *emplecton* of the Greeks. In these the stones were small, and laid with mortar; but when larger stones were employed no mortar was used. In great works the stones used by the Romans were sometimes of enormous size: the blocks of the architrave and frieze of the Portico of the Pantheon, extending from column to column, are each 15 feet in length, 6 ft. 8 in. in height, and nearly 6 feet in thickness; the angular blocks are above 17 feet in length; some of these stones weigh as much as 36 tons. At Baalbec, many of the stones are from 29 to 37 feet in length, and 9 feet in thickness, and one measures 62 ft. 9 in. in length, in one single block. Towards the decline of the empire, the *emplectum* was much used, either with or without courses of tiles; this is the kind of masonry usually met with in the Roman works in England and France. Mortar was frequently made with pounded brick, which gave it a reddish tinge; but where procurable, the Romans used puzzolano. The puzzolano cement was of two kinds; one, blacker and more ferruginous than the other, was employed in buildings exposed to the action of water. The channels of the water-courses were laid with cement, two or three inches thick, and are still as smooth and compact as if chisselled out of solid stone. When any structure was to be preserved from damp a double wall was built, with about a palm interval between. The method of marking out foliage in decoration may here be mentioned: a deep circular hole was drilled at each division of the leaf, thus assisting the effect of light and shade, and giving great boldness and decision of character. The Romans were no less skilful as workers in metal; four bronze columns, of exquisite workmanship, are still preserved in St. John Lateran, supposed to have belonged to the Temple of Jupiter Capitolinus; and the bronze gates of the Pantheon, and several others, are still considered pre-eminent in beauty.

With the exception of the Pantheon, the Flavian Amphitheatre, and a few others, all the magnificent buildings with which the Imperial City was once adorned, are so completely in ruins, that Rome has not inaptly been termed "a marble wilderness." Of many of these ruins it is difficult—of some impossible—to trace the plan, or to decide upon their proper designation. Gibbon ascribes this devastation to four principal causes: injuries of time and nature, hostile attacks, use of materials, and domestic quarrels. Owing to their solidity of construction, time, unaided by other causes, might have spared us most of the great structures of classical times; but besides frequent conflagrations, Rome was formerly exposed to the floods of the Tiber, which often caused great destruction. This danger is now removed, as the city is raised fourteen or fifteen feet above its original level. Besides these causes of decay, Rome (in 410 A.D.), was plundered by the barbarians under Alaric; and afterwards another horde, under Genseric, pillaged the doomed city for fourteen days. Much of what the Goths and Vandals had spared fell a prey to domestic rapine. In the middle ages the remains of ancient Rome formed a vast quarry, from which materials were unscrupulously taken for the construction of new edifices. The Coliseum owes much of its ruin to this cause; it is said, that as many stones were carried away from it in a single night as built the Farnese Palace. The Theatre of Marcellus became the Palazzo Orsini, and the Arch of Titus a fortress in the hands of the Frangipani family. Other buildings have been appropriated to different purposes, and extensive repairs and alterations been made, so that it is sometimes difficult to distinguish the new from the old: thus temples and basilicas have been converted into Christian churches, and statues of heathen gods made to do duty as Catholic saints. The same causes of decay prevailed in most of the provincial cities. The generality of Roman temples were similar in plan to the Greek, and were, like them, divided into the seven classes described in a former lecture; they were also frequently surrounded by an extensive peribolus, the wall of which was sometimes as high as the pediment of the temple. The peribolus wall was adorned within by a peristyle, or with niches and statues, and often contained apartments for the officiating priests. The principal difference between the Greek and Roman temples arose from the greater population of Rome, and the consequent greater space required. Thus in the prostyle temples, the porticoes were generally of the pseudo-dipteral form; and as they were mostly built on level ground, a greater elevation was given to the stylobate, in order to raise them above the surrounding buildings. A flight of steps, sometimes as many as twenty-one, led up to the portico in front; the acrotreria on each side terminating the podium, were decorated with statues; and in the larger temples statues occupied the place of antefixæ on the roof. The Romans adorned their temples with lavish profusion; when Domitian restored the Temple of Jupiter Capitolinus, the gilding alone is said to have cost 12,000 talents, a sum nearly equal to two millions sterling.

The Temple of Peace was one of the largest and most magnificent in Rome; the central aisle was 83 ft. in breadth, surmounted by a vault 150 ft. in height; three lofty arches, each 80 ft. span, yet remain; here were deposited the sacred vessels brought by Titus from the temple at Jerusalem.

One of the most perfect Roman temples now remaining is that of Caius and Lucius Cæsar, generally known as the Maison Carrée at Nismes. It is of the Corinthian order, 74 ft. in length, by 41 ft. in breadth; prostyle and hexastyle, with a pseudo-dipteral portico; engaged columns are placed round the exterior walls of the cella; the columns are rather more than ten diameters in height, and the capital, which is of elegant design, is somewhat more than one diameter high. The frieze in front is occupied by an inscription, but on the flanks is sculptured with foliage. The entablature rather exceeds 2½ diameters in height; the doorway is elaborately ornamented, and surmounted by a lofty cornice. This temple is ascribed to the time of the Emperor Hadrian. Besides the seven classes, the Romans had another form of temple, derived from the Etruscans, and by them probably from the east; this was the circular, symbolical of the earth and the heavenly bodies, and dedicated to Vesta or Cybele. The Pythagoreans believed fire, which they called Vesta, to be the centre of the universe; and Plutarch mentions a circular temple, which the Etruscan King Numa Pompilius erected to contain the sacred fire. Several circular temples are still in existence, as the Temples of Vesta at Rome and Tivoli; but the greatest ever built, and also the one in best preservation, is that dedicated to Jupiter, Cybele, and all the gods, by Agrippa, son-in-law to Augustus, and called the Pantheon or Rotunda. It is uncertain whether the body of the edifice existed previously, Agrippa only adding the portico, or whether the whole may be ascribed to him; the former is probably the case. It was injured by fire some time after its erection, and was repaired by Septimus Severus and Marcus Antoninus. After suffering from neglect for many years, it was granted by the Emperor Phocas to Pope Boniface, who dedicated it to the Virgin Mary and the holy martyrs (610, A.D). The Pantheon originally stood seven steps above the ground, but the earth has accumulated so much round it, that it is now below the level. The body of the temple is 143 ft. diameter, and 143 ft. in height to the top of the dome; it is constructed of brick; the exterior was formerly coated with stucco or cement, and the dome covered with plates of bronze, but these were removed by the rapacious Emperor Constans, during his visit to Rome. The walls are 20 ft. in thickness, and gradually diminish to 5 ft. as they approach the summit of the dome. The exterior height is divided into three parts by cornices of brick; the two upper cornices have stone modillions; the second rises in front, so as to repeat the form of the pediment. From the third cornice, the wall recedes about 8 ft., then follows a podium or surbase, and six steps, from which the dome rises. The two towers are modern, and were erected by Pope Urban VIII., part of the second cornice being cut away to receive them. The portico of the Pantheon is justly considered one of the most beautiful remains of antiquity. It is of the Corinthian order, octostyle, systyle, and dipteral. The sixteen columns supporting the pediment are 46 ft. 5 in. in height, and 5 ft. lower diameter; the shafts are plain, the exterior range of grey granite, the interior of red Egyptian granite in one block; the bases and capitals are of white marble; the entablature (also of white marble) is nearly one-fourth the height of the column. Opposite the interior range of columns are fluted pilasters of white marble, between which are bas-reliefs; the spaces between the pilasters on the flanks are also decorated with bas-reliefs. On each side of the doorway are niches, the one formerly occupied by the statue of Augustus, the other by that of Agrippa. Critics have objected to the depth of the tympanum, but it must be remembered that the Roman roofs were more elevated than those of the Greeks, on account of the difference of climate; and the effect of the high pediment would be much relieved by the sculpture with which it was formerly ornamented. The doorway is 39 ft. in height, and 19 ft. in width, with imposts and cornice of white marble; the doors are perforated at the top to admit of light and air.* The mass of brickwork of which the wall is composed, is lightened by seven exhedræ or chapels, which surround the interior, and also by small vaulted chambers above; the weight over each opening is discharged by arches seen on the exterior. The chapels have each two Corinthian columns *in antis*, of giallo antico, or pavonazetto marble; the architrave and cornice are of white marble, the frieze of porphyry; it is said, that before the restorations of Septimus Severus, the interior columns had capitals of Syracusan bronze; the interior order is lighter in character than the exterior, and the shafts of the columns are fluted. Between the chapels are tabernacles, each with two isolated columns backed by pilasters. The large recess opposite the entrance was formerly occupied by a statue of Jupiter, but is supposed to have been altered from its original form for the reception of the high altar. Above the lower order is an attic with a continuous pedestal or surbase; it is now decorated with small pilasters and panels of different coloured marbles let into the wall, the pilasters having capitals of white marble in low relief; these are, however, comparatively modern, as anciently the entablature was supported by thirty-four caryatides or telamones. In the dome are deep cassoons, twenty-eight in the circumference and five ranges in height; in the centre of each was a rose of gilt bronze; the plain part of the dome was silvered. The whole of this splendid edifice receives light from a circular aperture, 28 ft. diameter, called the eye of the vault; in the attic are fourteen windows, but these do not communicate with the exterior, but are intended to give additional light to the chapels from the centre opening. The pavement is tesselated with granite, porphyry, jasper, and marbles; it inclines towards the centre to prevent the rain falling through the roof from deluging the floor. The aperture was occasionally covered by a velarium. Such is the Pantheon. "Spared and blest by time, simple, erect, severe, austere, sublime," as Byron describes it, we may imagine its imposing effect in its days of pristine splendour.

The circular temples of Vesta at Tivoli and Rome, are peripteral, the former surrounded by a peristyle of eighteen fluted Corinthian columns, 9½ diameters in height; the latter, by twenty columns, nearly 11 diameters in height. In these small circular peripteral temples the interior diameter of the cella was the same with the height of the column; they were lighted by windows, and were supposed to have had vaulted roofs terminating in flowers or antefixæ. From its picturesque situation on the edge of the cliff, the Temple of Vesta at Tivoli has been an unfailing subject for the landscape painter, from the time of Claude to the present day. Vitruvius mentions another kind of round temple, with a domical roof supported by columns without a cella, called monopteral: of these we have no examples.

Before leaving the subject of the sacred buildings of the Romans, the ruins of Baalbec and Palmyra claim our attention, both belonging to the latter ages of the empire. Baalbec, or Heliopolis, so called from the worship of Baal or the Sun, was one of the chief cities of Cœlesyria, whose inhabitants were renowned in early times for their magnificence and luxury.

It is uncertain to which reign the great temple is to be ascribed; some authors attribute it to Antoninus Pius—others to Septimus Severus. John of Antioch says, "Ælius Antoninus Pius built a great temple to Jupiter at Heliopolis, near Libanus, in Phœnicia, which was one of the wonders of the world. The ruins are so vast, that the Arabs believe the buildings to have been the work of fairies or genii. A grand portico leads into a hexagonal court, and this into a quadrangular peribolus, at the end of which is the great temple; in the first court are chambers, which are supposed to have been schools, and apartments for the priests. The portico, or propyleum, is flanked by projections or towers, on which modern fortifications have been raised. The great temple is of the Corinthian order, decastyle, with nineteen columns on the flank. It is 900 feet in length, and 450 feet in breadth; the columns are 7 feet lower diameter, 6 ft. 5½ in. upper diameter, and 58 feet in height. The whole height of the order is 87 feet. A smaller temple stands near, octostyle and pseudo-dipteral, also of the Corinthan order. The whole of the buildings are of white marble, and as sumptuously enriched as the luxury of art could devise. The ornament on the frieze is the same in both temples, and is most singular; it consists of a row of modillions set on end, connected by ribbons and garlands, with a grotesque head carved under the upper scroll of each modillion. A small temple still exists at Baalbec, in good preservation, which is unique in form. The cella is circular, 32 feet diameter, with a peristyle of eight columns, six of which are about 10 feet distant from the cella; the entablature curves so as to touch the wall, the columns only supporting the projecting angle formed by the meeting of two curves. The same elliptical curve is repeated in the stylobate; the frieze is rounded, and the wall of the cella ornamented on the exterior with niches.

Palmyra, rising like an island from the sandy desert, received its name from its multitude of palm trees. It is supposed to be the same as the Tadmor of King Solomon. This city long preserved its independence, on account of its situation in the desert, and as a frontier town between Parthia and the Roman empire, and carried on the principal trade between Rome, India, and Arabia. Palmyra is best known to us as associated with the names of Zenobia and Longinus. This once wealthy and important city, the abode of princely merchants, has now dwindled to a few miserable mud cottages, erected within the court of its once magnificent temple. The date of the foundation of the great temple is unknown; but from inscriptions it appears to have been repaired by the Emperors Hadrian, Aurelian, and Justinian. It is octostyle and pseudo-dipteral, and stands in the midst of a spacious peribolus, 740 feet long by 720 feet broad. The peribolus is surrounded on three sides by a double peristyle; on the west is the noble propyleum and the priests' apartments: the exterior wall is decorated with Corinthian pilasters. In the great portico or propyleum are the niches, with coupled columns and semicircular pediments before mentioned. The ornaments, particularly of the doorways and soffits, are elaborately beautiful. The whole of the ruins of Palmyra are of the Corinthian order, with the exception of four engaged Ionic columns in the great temple, and two in one of the tombs.

The architecture of Palmyra is precisely similar in style to that of Baalbec; both exhibit the florid taste of the east rather than the simplicity of classical art; but whatever defects may be perceptible, it is impossible not to admire the grandeur of the conception, the boldness of the execution, and the great skill displayed in construction. Before entering upon the civil architecture of the Romans, I shall briefly notice their tombs and mode of sepulture. It was the universal custom (with the exception of a few of their greatest men) to bury without the walls: monuments are therefore found extending on both sides of the roads, beyond the gates of the cities; they are of various forms, generally richly ornamented, frequently with bas-reliefs, painted in colours. The tomb of Cæcilia Metella at Rome is a circular building, so massive that it at one time served as a fortification. The Castle of St Angelo was formerly the Mausoleum of Hadrian, built by that emperor as a depository for his own remains and those of his successors, several of whom repose there. It is a circular structure raised upon a square basement. It was originally cased with marble, and surrounded by a peristyle; but the columns, as well as the statues with which its summit was adorned, have long since disappeared.

The kind of sepulchre peculiar to the Romans, from their custom of burning their patrician dead, was the Columbarium, so called from its resemblance to a dove-cote. This was a square chamber with rows of [illegible] for the reception of cinerary urns or chests. In [illegible] the entrance, a statue or bust of the founder of [illegible] frequently placed. The columbaria only receiv[illegible] funeral lamps or torches, borne by the [illegible] rank, were buried [illegible]

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* See Professor Donaldson's Examples of Ancient Doorways.

The civil and domestic architecture of the Romans will be described in the next Lecture, beginning with the roads and aqueducts, and proceeding with the Fora, Basilica, Amphitheatres, Thermæ, and other characteristic buildings.

LIST OF AUTHORITIES.

Vitruvius—Decline and Fall of the Roman Empire, Gibbon.—Architectural Antiquities of Rome, Taylor and Cresy.—Les Edifices Antiques de Rome, Desgodets.—De Romanorum Magnificentia, Piranesi.—Le Cinque Ordini, Vignola.—Monumenti e Fabbriche Antiche, Cipriani.—Antiquités de la France, Clerisseau. Ruins of Baalbec and Palmyra, Wood.—Pompeiana, Sir William Gell.—Encyclopedie Methodique—Architettura, Serlio.—Architettura, Palladio.

LIGHTHOUSE.

A LIGHTHOUSE of a somewhat peculiar construction has just been completed at the extensive works of Messrs. Fox, Henderson and Co., Smethwick, the following description of which may not be uninteresting to our readers:—The structure consists of a cast-iron tower, or hollow column, of a conical form, 70 feet high from high water to the top of the lantern; 12 ft. 6 in. diameter at the base, and 10 feet diameter at the top. It is composed of fifteen horizontal tiers of segmental plates, each tier 5 feet high, and so divided that no one plate exceeds 7 feet in breadth. The plates are provided with flanges, strengthened with brackets, and having bolt-holes with bosses opposite each other for bolting together. The thickness of the plates varies from 1¼ to 1¾ inch. Round the bottom tier of plates there is a large flange, through which a number of long holding-down bolts pass to secure it to the foundation. In the second tier of plates there is a strong cast-iron door, accurately fitted, leading to the staircase, which winds round a central column. Equally distributed throughout the tower are six windows, to give light to the staircase. They are of a circular form, and the frames are made of cast-iron, secured to the plates, and glazed with plates of glass ⅜ths of an inch thick. The entrance-door at the foot of the tower is 6 ft. 8 in. high, and 3 ft. 6 in. in width. The hinges are of brass, and fixed to the door and frame with countersunk headed tap-screws. The gallery platform at the summit of the tower, for the support of the lantern, consists of cast-iron radial plates, ¾ths of an inch thick, truly-pointed, fitted, and bolted together. The projectional portion of the platform rests upon eight cast-iron brackets, filled and fixed to the upper tier of segmental plates of the tower. The gallery platform is provided outside with a railing of wrought iron, 3 ft. 6 in. in height, consisting of baluster-rods, fitted to a rail at the top and bottom. The top of the spiral staircase is provided with a deal-boarded inclosure and a deal door, forming a bulk-head, to prevent any draught entering the lantern. The lantern is 10 feet in diameter over all, and 11 ft. 6 in. high from the floor of the gallery to the underside of the roof. The lower part, or plinth, is 5 ft. 6 in. high, and constructed entirely of cast-iron plates lined with wood. One-half of the lantern consists of cast-iron plates, lined with wood, and the other half is glazed with flat plate-glass fixed in gun-metal sash-frames, and fastened with putty and metal pins. The roof is composed of double plates of sheet copper. A copper ventilator and a dart weathercock is fixed to the top of the lantern, and a lightning-conductor, tipped with gold, has been added. The whole of the cast and wrought-iron is painted in oil colour, with the exception of the bolts and nuts, which are thoroughly coated with coal-tar. The lantern is provided with a reciprocal light illuminating 120° of the horizon, consisting of fourteen Argand lamps and fourteen plated reflectors of the most approved construction. The lantern is reached by ninety-eight steps of cast-iron. The lighthouse, on being completed, was, according to agreement, erected on the premises, and all the parts connected, and it is at present standing in its complete state on a rising ground near the canal. On two occasions the lantern has been lighted, and produced a wonderful effect—surpassing expectation—and at night was seen at an immense distance. The drawings, &c., were supplied by Mr. Cowper, the eminent engineer at the London Works. The lighthouse is for the East India Company, and its destination Middleton Point, Saugor Island, India.—*Birmingham Gazette.*

NEW YORK.—A new bank, called the Pacific Bank, has been built in Broadway. The well-known hotel, the Astor Hotel, is being repaired and enlarged. At no period was there ever such activity in building in New York, or such quantities of building materials brought into the city.

ON DEDUCTIONS FROM METEOROLOGICAL OBSERVATIONS.

On Deductions from Meteorological Observations. By JOHN DREW, Esq., F.R.A.S., Member of the Council of the British Meteorological Society.

THE efforts of the British Meteorological Society are directed, for the present, to the attainment of mean monthly values of atmospheric phenomena for various localities. My last paper directed attention to the absolute necessity of referring all observations to acknowledged standards; and pointed out the means by which observers in districts widely dispersed, might be certain that the indications of their instruments were in accordance with truth. Presuming that the possessors of trustworthy instruments are competent to record their observations accurately and faithfully, it is my intention, in continuing the subject, to devote the present essay to the explanation of certain legitimate deductions from thermometric and barometric registrations.

To be able to compare the observations recorded in various quarters in a manner the most immediate and direct, it is of importance that the daily registration should be conducted by each observer on precisely the same plan; so that on the transmission of the series to head quarters, a comparison of column with column may be made at a glance. To facilitate this essential object, the Council of the British Meteorological Society, at its meeting in July, agreed upon a form of registration which has since been printed, and which may be obtained from Mr. Glashier, the Honorary Secretary, by all those who are anxious to co-operate in the objects of the Society. Each sheet is ruled for one month; and the following copy of the heading will show the extent of the demand on an observer's industry:—

Moon's Age.	Day of Week.	Day of Month.	At A.M., Local Time.					
			Reading of					
			Barometer	Attached Therm.	Dry Bulb Therm.	Wet Bulb Therm.	Wind.	
							Direction.	Force 0—6.

At A.M., Local Time.						Prevalent Diseases.	Leafing, Budding, Flowering of Hardy Plants, Forest Trees, &c.; and Arrival and Departure of Migratory Birds.
Reading of Self-Registering Thermometers.				Rain fallen in previous 24 hours.			
Max. in Air.	Min. in Air.	Max. in Rays of Sun.	Min. on Grass.	On the ground.	feet above ground.		

Notation used in General Remarks.					
a.	*denotes*	aurora.	m.	*denotes*	meteor.
ci.	,,	cirrus.	ms.	,,	meteors.
ci-cu	,,	cirro-cumulus.	n.	,,	nimbus.
ci-s.	,,	cirro-stratus.	r.	,,	rain.
cu.	,,	cumulus.	h. r.	,,	heavy rain.
cu-s.	,,	cumulo-stratus	c. h. r.	,,	continued do.
d.	,,	dew.	s.	,,	stratus.
f.	,,	fog.	sc.	,,	scud.
fr.	,,	frost.	sl.	,,	sleet.
h-fr.	,,	hoar-frost.	sn.	,,	snow.
h.	,,	haze.	so. ha.	,,	solar halo.
h. d.	,,	heavy dew.	sq.	,,	squall.
hl.	,,	hail.	sqs.	,,	squalls.
l.	,,	lightning.	t.	,,	thunder.
li. cl.	,,	light clouds.	ts.	,,	thunder storm.
li. sh.	,,	light showers.	w.	,,	wind.
lu. co.	,,	lunar corona.	g.	,,	gale of wind.
lu. ha.	,,	lunar halo.			

Occasional simultaneous Readings of Self-Registering Thermometers at times of Ordinary Observations.			
Max.	Min.	Max. Sun.	Min. Grass.

Sums of the observations during the month .. .. ..

Means .. ..
Index errors .. ..

Correction for Diurnal Range .. ..

Means corrected .. ..

From the adopted Mean Temperatures of Air and Evaporation, the following hygrometrical results are to be calculated by Glaisher's Hygrometrical Tables.

The Temperature of the Dew-point .. ..
The elastic force of Vapour .. ..
The weight of Vapour in a cubic foot of Air .. .. ..
The additional weight of Vapour required to saturate a cubic foot of Air .. ..
The degree of Humidity (complete saturation = 1) .. ..
The average weight of a cubic foot of Air .. .. ..

The original register, or a verified copy, is to be transmitted, at the end of every month, to the Secretary of the British Meteorological Society, 18, Dartmouth Terrace, Blackheath, Kent.

The atmosphere which surrounds our globe is subject to agitations far more extensive than the swell of the ocean; waves as broad as the Atlantic itself pass over us from time to time. Independently of these atmospheric waves, hourly variations in the pressure of the air have been determined, which seem to follow a definite law. One of the causes of these fluctuations is variation of temperature; another is the union with the aërial of an aqueous vapour. Such is the tendency of the air to unite with the vapour of water that it may be said, in no case, to be found in a state of absolute dryness: the supply is obtained from rivers, the ocean, the surface of the soil. The very laws of nature tend to its distribution—winds and atmospheric currents lead to its equable diffusion. We may, indeed, consider the globe to be surrounded with two co-existing atmospheres—the one of air, and the other of aqueous vapour—not chemically combined, but commingled, or mechanically united; the one being, as it were, diffused throughout the pores of the other, as water through the substance of a filtering vessel or the pores of sponge; and they may be, for the sake of experiment, as readily separated as the sponge may be relieved of its aqueous burden by compression. As the sponge, moreover, by its elasticity will recover its size, as before, so if we deprive a cubic foot of air of its moisture it will occupy the same space, though its density will be less. The experiments of Dalton and others have proved this remarkable fact, that under similar circumstances as to temperature and pressure, the quantity of watery vapour existing in air will be exactly equal to what it would be in a vacuum of equal capacity; and that, if we have the means of computing the pressure or weight of vapour in vacuo, we shall be able to determine with equal accuracy the actual weight of moisture in a given volume of air by the same means; in fact that, in either case, the pressure will be the same.

The capacity of air for moisture increases with the temperature; but there is a limit to its power of holding aqueous vapour in solution; when this limit is attained, the air is in a state of complete saturation. If from any cause a volume of air in this condition should be suddenly cooled, a deposition of moisture succeeds; the air parts with aqueous vapour in minute particles; and if it be free from agitation these appear in the form of *dew*, which is witnessed in perfection after the removal of the heat of the sun on a still autumnal night. The effect of a temperature below the freezing point will be to convert the dew into *hoar frost*, as is visible when winter approaches.

Should the air part from its moisture at a distance from the earth's surface, the aqueous particles will separately descend but slowly, or not at all. By the law of aggregation, they will unite in globular forms, and their united weight being now sufficient to overcome atmospheric resistance, they will be attracted towards the earth, and fall in the form of *drops of rain*. That electricity is concerned in the production of rain is more than probable; and this opinion is confirmed by the fact that copious and heavy showers fall during a thunder-storm.

Dry air is denser than the vapour of water, and a mixture of the two will be lighter than the same volume of dry air alone. Thus we find the mercury of the barometer will indicate a decrease of pressure on a damp foggy day; whereas it will be found to rise in fair dry weather. Most of the variations indicated by the barometer arise from the greater or less degree of moisture existing in the air; and the interchange of aërial strata of various densities, and in various conditions as regards heat, produces all the fluctuations of pressure observed. Whether these are only the lower strata of the atmosphere—how high they extend—whether the height of the atmosphere above the earth's surface is invariable—are questions for science to determine.

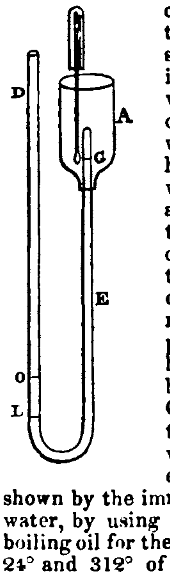
Evaporation and condensation of aqueous vapour tend, in various ways, to diffuse heat more equally throughout the globe. As the power of the air to imbibe moisture increases with the temperature, evaporation goes on with most rapidity in warm climates, and the heat absorbed in the process has a cooling tendency. Strata of warm air, elevated by the in-rush of cooler draughts, are driven to regions where the temperature is lower; here the vapour is condensed, and its latent heat is given forth to mitigate the severity of the colder climate.

If two saturated volumes of air of unequal temperature, and therefore of varying capacities for moisture, meet each other, their tendency will be to unite and equalise both the temperature and the moisture. The moisture, however, will always be in excess, for the two processes will not proceed at the same rate. Thus, supposing two volumes of air, one of the temperature of 40°, and the other of 60°, to unite, the mean temperature of the mass will be 50°. The elastic force of vapour at 40° of temperature (as will be explained more fully hereafter) is ·264 measured as pressure in inches of mercury; at 60° it is ·523; but at 50°, the mean of the two temperatures, the elastic force is ·373, which is less than ·394 (the mean of the others) by ·021: this represents the tension of that portion of moisture which would be set free. If this vapour, in its liberated state, meet with a stratum of air not saturated with moisture, it will be re-absorbed either partially or entirely; if only partially, the remaining portion, consisting of aqueous vapour in an extremely minute state of subdivision, may be arrested in its descent, and float in the atmosphere in the form of *clouds*.

From the preceding observations it will appear that the pressure shown by the barometer is compounded of that of the air itself, and the co-existing vapour of water, from which it is never entirely disunited. It will now be shown in what manner these two forces may be separated, and the proper value assigned to each. We shall then be led to appreciate the simplicity of the process of deducing the hygrometric state of the atmosphere from simply observing the difference between dry and wet bulb thermometers; in other words, by remarking the difference between the temperature of the air and the temperature of evaporation.

Tension of Aqueous Vapour.

The experiments of Dalton, and more recently of Dr. Ure, Regnault, and others, have been the foundation of tables, showing the elastic force of vapour as measured in inches of mercury for every degree of temperature. Since many of the deduced results depend upon these, a description of the method employed by Dr. Ure in determining the tension of vapour may tend to give confidence in the results.



D L E is a syphon barometer, the leg E being closed, and the other open at D. On the admission of the mercury there will, of course, be an equilibrium when the column in the closed leg balances the atmospheric pressure on the surface of the mercury in the other, and the space above G will be a vacuum; a glass vessel is adapted to the outside of this portion of the tube, and rings of platinum wire on the exterior of the tube serve to mark the height of the mercury in each leg. A drop of water is now introduced into the vacant space above G, which is forthwith changed to vapour, and the vessel A is filled with water, the temperature of which is shown by the thermometer inserted therein. The tension of the vapour will of course cause the mercury to descend in the tube E, and rise in the tube D; a portion of the metal is now poured into the open tube until its weight counterbalances the tension of the aqueous vapour, and brings the mercury to its original level at G. Let O L be the space occupied by the additional quantity of mercury; this space, accurately ascertained, will be the measure, in inches of mercury, of the elasticity of aqueous vapour at the temperature shown by the immersed thermometer. By varying the heat of the water, by using freezing mixtures for the low temperatures, and boiling oil for the higher, Dr. Ure obtained results ranging between 24° and 312° of heat; the elastic force for the former being 0·17 inch, for the latter, 167 inches.

The Greenwich Meteorological Observations contain "*A Table, showing the Elastic Force of Vapour in inches of Mercury for every tenth of a degree, from* 0° *to* 90°*:*" an extract from it is here given, to illustrate its use in the subsequent deductions.

Temp. Fahr.	Force of vapour in inches.	Temp. Fahr.	Force of vapour in inches.
31	0·192	34	0·214
32	0·199	35	0·222
33	0·207	36	0·230

Temp. Fahr.	Force of vapour in inches.	Temp. Fahr.	Force of vapour in inches.
37	0·238	41	0·274
38	0·246	42	0·283
39	0·255	43	0·293
40	0·264	44	0·304

Dew-Point.

If a volume of air of the temperature of 35° be saturated with moisture, it follows that the tension of such moisture is equivalent to ·222 of an inch of mercury. Hence, if the barometer reading be 29·886, the pressure due to air alone, supposing it to be deprived of its vapour, is 29·886 — 0·222; or, 29·664.

Complete saturation, however, is of comparatively rare occurrence: only, indeed, when the readings of the wet and dry bulb are alike. In every other case the air is capable of retaining a greater quantity of aqueous vapour. The knowledge of the dew-point here comes to our assistance. The dew-point gives a temperature to which, if we suppose any volume of air reduced, it would be saturated with the moisture contained within it. This point may be ascertained immediately by means of Daniell's hygrometer, as was shown in my last paper. Entering the table then with the temperature of the dew-point, or that temperature at which the air would be ready to part with its moisture, we ascertain, as before, the tension of aqueous vapour under any given condition of the atmosphere.

Thus, supposing that dew begins to be deposited at 31°, the air being of any temperature, we enter the table with 31°, and find the tension of aqueous vapour 0·192 inches; which, subtracted from the reading of the barometer, will give the pressure of dry air.

If the dew-point is not directly ascertained, it must be inferred from simultaneous observations of the dry and wet bulb thermometers, by means of Glaisher's factors, to be spoken of presently. In Mr. Glaisher's practice, he at times experienced difficulties in the use of Daniell's hygrometer; and at times he found that the simultaneous results of the dew-point, as found from Daniell's hygrometer and the dry and wet bulb thermometers, were discordant: and on investigating these causes, he found that the error rested alone with Daniell's hygrometer. The times at which these discordances existed were in those particular states of the air when great dryness was prevalent; and the depression of the temperature of the dew-point below that of the air was great, and a long time elapsed after the dropping of ether on the white ball before dew was deposited on the black ball. Such would require the long continuance of the observer near the instrument, and this necessarily would influence both the hygrometrical state, as well as the temperature of the air around the instrument; and this would be especially the case if the observer be short-sighted, and obliged to approach the instrument very nearly. And he makes the following objections to the use of this hygrometer:—

"Supposing the inclosed thermometer to be one of extreme delicacy, which it is not, it would then indicate the temperature of the portion of ether only in which its bulb was in contact, and which portion may be very different from that which is below it; and may be very different indeed from that part of the outside of the glass upon which the dew is deposited. And if the ether be dropped very slowly upon the white bulb, so that evaporation should proceed slowly, the evil of long-continued watching is required; and if more quickly, then the different layers of the inclosed ether is of different temperatures. It must also be recollected that the situation of the black ball, upon which the deposit of dew takes place, is not very far from the white ball; and in cases where large quantities of ether are necessary, such must influence materially the hygrometrical state of the air in the space included by both bulbs."

In consequence of these sources of error in the use of Daniell's hygrometer, together with its expense in use and trouble in using, Mr. Glaisher made many attempts, by different combinations of the results derived from the observations of the dry and wet bulb thermometers, to deduce the temperature of the dew-point from them; and at last found that the difference between the temperatures of air and dew-point, divided by the difference between the temperatures of air and evaporation, was constant at the same temperature; but that this value was different with every different temperature.

He then collected all the simultaneous observations which had been made at Greenwich, every two hours, from the year 1840 to 1844, and from them deduced the following table:—

Table of Factors, by which the Difference of Readings of the Dry Bulb and Wet Bulb is to be multiplied, in order to produce the Difference between the Readings of the Dry Bulb and Dew-Point Thermometers.

Reading of the Dry-Bulb Thermometer.	Factor.	Reading of the Dry-Bulb Thermometer.	Factor.	Reading of the Dry-Bulb Thermometer.	Factor.	Reading of the Dry-Bulb Thermometer.	Factor.	Reading of the Dry-Bulb Thermometer.	Factor.	Reading of the Dry-Bulb Thermometer.	Factor.
20°	8·5	32°	3·1	44°	2·3	56°	1·9	68°	1·6	80°	1·5
21	8·5	33	2·8	45	2·3	57	1·9	69	1·6	81	1·5
22	8·5	34	2·6	46	2·3	58	1·9	70	1·5	82	1·5
23	8·5	35	2·6	47	2·2	59	1·8	71	1·6	83	1·5
24	7·3	36	2·6	48	2·2	60	1·8	72	1·5	84	1·5
25	6·4	37	2·5	49	2·2	61	1·8	73	1·6	85	1·5
26	6·1	38	2·5	50	2·1	62	1·7	74	1·5	86	1·6
27	6·1	39	2·5	51	2·1	63	1·7	75	1·5	87	1·5
28	5·7	40	2·4	52	2·0	64	1·7	76	1·6	88	1·5
29	5·0	41	2·4	53	2·0	65	1·7	77	1·5	89	1·6
30	4·6	42	2·4	54	2·0	66	1·6	78	1·6	90	1·5
31	3·7	43	2·4	55	2·0	67	1·6	79	1·5	91	1·5

On the Weight of Vapour in a Cubic Foot of Air.
On the Weight of a Cubic Foot of Air,
On the Amount of Vapour required for Complete Saturation.
On the Degree of Humidity of the Atmosphere.

It has been experimentally determined by M. Gay-Lussac, that air expands $\frac{1}{480}$th part of its bulk for every addition of 1° of heat, inasmuch as it expands equally with equal increments of heat from the freezing to the boiling point, to the amount of $\frac{3}{8}$ of its bulk. Taking a cubic foot of dry air at a pressure of 30 inches, and a temperature of 32° as unity, a simple proportion will give the space it will occupy when subject to any given degree of temperature—say 44°.

Now, by the addition of 180°, we find the expansion $\frac{3}{8}$ of the volume (viz., from 32° to 212°); required the expansion for 44 — 32, or 12°.

$180° : 12° :: \frac{3}{8} : \frac{1}{40}$, so that the cubic foot of air becomes 1·025 ft.

From determinations of the weight of a mass of dry air under a pressure of 30 inches by Sir George Shuckburgh, Biot, and Thènard, it is inferred that a cubic foot of dry air, at 32°, under pressure of 30 inches, weighs 563 grains; whence we may determine its weight after expansion by heat (say, at a temperature of 44°), by the following proportion:—

1·025 feet : 1 foot :: 563 grains : 549·27 grains.

The next step is to ascertain the enlargement which a volume of dry air receives when saturated with vapour at any degree of temperature; but in the examples, 44° will be the degree assumed, and a cubic foot the volume.

If a cubic foot of dry air, of known elasticity, be mixed with a cubic foot of vapour, also of known elasticity, and if the mixture be compressed into the space of one cubic foot, the elasticity of the mixture will be the sum of the two elasticities of the air and vapour; or, if it be allowed to expand till its elasticity is equal to that of the unmixed air (suppose 30 inches), it will occupy a larger volume, in the proportion of the sum of the two elasticities to the elasticity of the air alone. Now, from the table, we know the elastic force of vapour for every degree of temperature; let it be required to find the space occupied by a mixture of a cubic foot of dry air and moisture at the temperature of 44°.

Tension of aqueous vapour at 44° =	0·304 inches
Tension of dry air	30·
	30·304 inches.

Then, $\frac{1}{30{\cdot}304} : \frac{1}{30} ::$ 1 c. f. : 1·01012 c. f., which is the space occupied by the mixture of the two aërial fluids.

The following formula will give the result in more general terms:—

Let p = the atmospheric pressure, as measured by the inches of mercury in the barometer.

E = the elasticity of vapour at a given temperature (measured in the same way.)

n = the bulk of a certain quantity of air, when dry, at the given temperature, and under the pressure p.

n' = the bulk of the same quantity of air when saturated with vapour at the same temperature, and under the same pressure p.

Then, since the elasticity varies inversely as the volume, the temperature remaining the same, that portion of the elastic force p, which depends on the air alone, which occupies the space n', is $p \times \frac{n}{n'}$;

and this, together with E, must make up the atmospheric pressure.

Or, $p = p \times \frac{n}{n'} + E$;

whence, $n' = \frac{n}{1 - \frac{E}{p}} = \frac{1}{1 - \frac{\cdot 304}{30}} = 1\cdot 01013$, as before.

In the Greenwich Meteorological Observations will be found a table calculated from this formula, for every degree, from 0° to 90°. From the introduction to the yearly volumes, the following formulæ and explanations are extracted:—

"Gay-Lussac has determined by experiment, that vapours, so long as they remain in an aëriform state, expand by the increase of temperature, precisely as permanently elastic fluids, and that they suffer changes of volume proportional to the changes of pressure; and he has, as previously stated, determined that air expands $\frac{3}{8}$ of its bulk from 32° to 212°, and that its expansion is uniform between these points.

Therefore, if the weight of a cubic foot of vapour, under the pressure of 30 inches of mercury, and at the temperature of 212°, be called W, and the weight—expressed in the same denomination—of an equal volume of vapour at the temperature t, be called W′, and, if Et be the elasticity of vapour at the temperature t, then (the expansion of dry air from 32° to 212° being 0·375, or being $\frac{1}{480}$th part, equals 0·002083 for each degree of temperature),

$$W' = \frac{1\cdot 375 \times W \times Et}{30\,(1 + \cdot 002083\,.\,\overline{t^\circ - 32})}.$$

Now, Gay-Lussac has also determined that a cubic inch of vapour, at 212°, weighs 0·149176 grains under the pressure of 29·922 inches of mercury; and, consequently, a cubic foot of vapour, under the same circumstances, weighs 0·149176 + 1728 = 257·776 grains; and under a pressure of 30 inches, it weighs

$$\frac{30}{29\cdot 922} + 257\cdot 776 \text{ grains} = 258\cdot 448 \text{ grains}.$$

Therefore, substituting this weight for W, the formula becomes

$$W' = \frac{1\cdot 378 \times 258\cdot 448 \times Et}{30\,(1 + \cdot 002083 \times \overline{t^\circ - 32^\circ})};$$

and from this formula may be formed a table, showing the weight of a cubic foot of vapour in grains, under the pressure of 30 inches of mercury for any range of the thermometer.

The degree of humidity shows, on a natural scale, the condition of the air as regards moisture; complete saturation being represented by unity, and the air absolutely deprived of moisture by zero. The numbers are obtained by dividing the quantity of vapour which the air contained at the time of observation, by the quantity which it would contain if it were in a state of complete saturation."

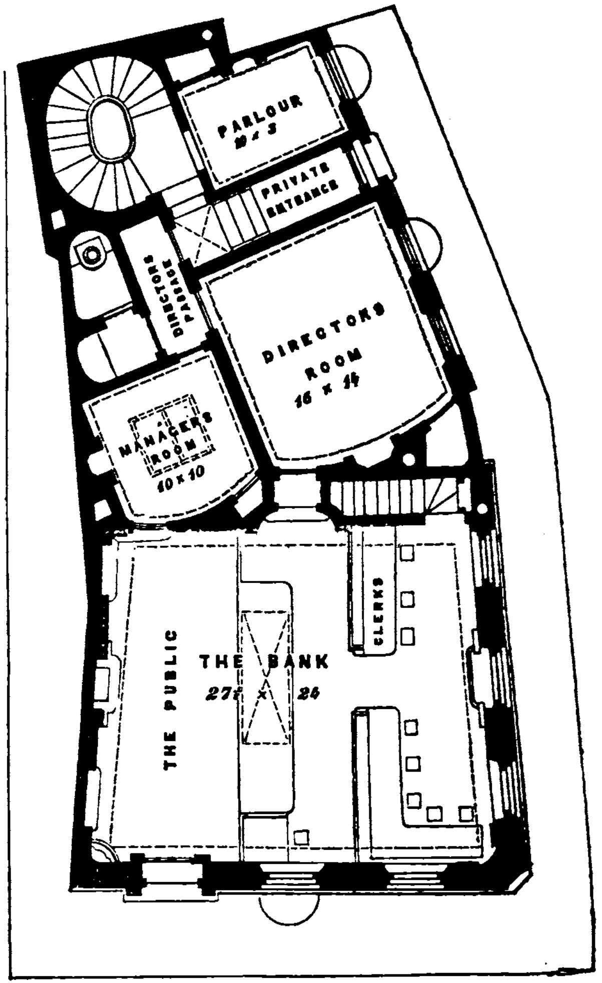
From these principles, combined with an extension of the calculations which I have not thought fit to enter upon, Mr. Glaisher has formed his hygrometrical tables, entering which with simply the readings of the dry and wet bulb thermometer, we are enabled to obtain by inspection—

1. The temperature of the dew point.
2. The elastic force of vapour in inches of mercury.
3. The weight of vapour in a cubic foot of air.
4. The weight of vapour required for saturation of a cubic foot of air.
5. The degree of humidity.
6. The weight in grains of a cubic foot of air.

(To be continued.)

YORKSHIRE AGRICULTURAL & COMMERCIAL BANK.

WE lately gave an engraving of a bank erected by Messrs. Atkinson, at Whitby; and in noticing another bank by them, we shall have occasion to make similar remarks. The bank now shown to our readers, is the office, at York, of the Yorkshire Agricultural and Commercial Banking Company. It is situated at the corner of High Ousegate and Castlegate, occupying an irregular plot of ground, but having a straight front towards High Ousegate. The style adopted is Italian, with a good cornice, and with rustications on the base. The height is in three stories, with a basement, being altogether about 60 feet above the level of the pavement. On the Castlegate side, which is of some length, it has been necessary to make the building on two lines, receding from the main front.



PLAN OF GROUND FLOOR.

The ground-floor, which contains the banking offices, is of a height of 18 feet, and has an entrance, and two windows with circular heads. The material used is rubbed or cleansed Park-spring stone, rusticated in the quoins, and with a base rusticated in panels, and, except where interrupted by doorways, carried around the building. The first floor is 13 feet high, and has three windows in front, ornamented with mouldings, brackets, and carving. On the Castlegate side are six windows.

By the internal arrangements the whole front of the ground-floor is appropriated as the banking office, making a room 27 feet by 24 feet, and 18 feet high. Behind this are the manager's room, director's room, and manager's parlour. The banking office is highly enriched and well fitted. The windows have Bunnett and Corpe's iron revolving shutters. The basement is made fire-proof, and contains two fire-proof rooms. Into one of these works a large iron safe, like that described for the Whitby Bank. It is under the front counter in banking hours, and descends into the vault by an hydraulic pump. A wrought-iron door closes this vault when the safe is down. The safe contains all the cash-drawers, and was provided by Dewer and Co., at a cost of 200*l.* The cost of the building, exclusive of counters and furniture, was nearly 4000*l.* The fire-proof vaults communicate with the bank above by a stair, and are shut off from the manager's private residence and offices.

YORKSHIRE AGRICULTURAL AND COMMERCIAL BANK.—J B. & W. Atkinson, Architects.

BLACKFRIARS AND WESTMINSTER BRIDGES.

Two of the metropolitan bridges over the Thames—those of Westminster and Blackfriars—are giving way, and threaten destruction, in consequence of the sinking of some of the piers.

The ruin of these bridges will inevitably take place if some immediate and effective means be not employed to prevent it; and the consequence will be, a loss to the public of millions, a great inconvenience for many years to the thoroughfare between both sides of the Thames, and to the navigation in the river. Let us inquire what is the cause of that threatening disaster? The probability of such a result was foretold, and debated long before the removal of the old London Bridge. In 1766, Smeaton gave an opinion, that if the fall at London Bridge was reduced, the navigation above the bridge would be injured by a reduction in the depth of water; and that the transverse section of the bed of the river would be altered, and in many places lowered, in consequence of the increased current of the water. Time has shown, that in this his opinion was correct, but not so in that; because the navigation has been much improved by the removal of the old London Bridge, which impeded the uniform flow of the water in the river, and dammed it up, causing a fall under the bridge, dangerous to the passage of boats and barges, except at the time of high water. This damming up of the water had for result to keep the current nearly null on the bed of the river above the London Bridge, because the greater the transverse section of the water, the smaller in proportion will be the velocity required to transmit a given quantity of water in a given time. This reduction of the velocity, in place of excavating the bed of the river, allowed it rather to fill up by the accumulation of mud or fine sand drifted from the higher part of the river. But as soon as the obstacle to the water was removed by the removal of the old bridge, then, as was anticipated by all parties (I believe), the current on the bottom of the river was increased, the mud and fine sand were removed down the river, and during freshets the larger sand and gravel were also removed; and as the piers of the bridges diverted the current, especially at low water, into particular channels, leaving other parts opposite the piers dry, or with very little water and current thereon, the deeper these particular channels became the stronger the current would at all times thereafter be; and thus the transverse section of the river's bed has become deformed, by being successively and continually deepened between the piers. But this deepening between the piers caused an incline plane to be formed, from the piers towards the middle of the arch, or the centre of the excavation formed by the current; and the gravel (of which the bed of the river is chiefly composed in the London district) would naturally roll or slide down into the cavity of the channel, and be carried away with the current. This work going on during a succession of years, has, of course, reduced the level of the ground around the piers, and under some of them; the consequence is too apparent to be doubted, and if not speedily remedied, may be deplorable.

That Westminster Bridge, under the circumstance I have endeavoured to explain, should first show symptoms of dislocation, is what might naturally be expected, because the piers are founded on caissons only, without any piles to sustain them, whereas the piers of Blackfriars Bridge are founded also on caissons; but the bed of the river under these caissons is piled, perhaps not very deep; but the ground being piled, whether deeply or otherwise, should, and has, resisted during a longer time to the action of the currents, as above described. If any other proof than common sense and reflection were wanting for the accuracy of these deductions, it will be found in the circumstance, that during the construction of Westminster Bridge the bargemen had imprudently been allowed to remove gravel from near to one of the piers, so that the pier near to which the excavation was permitted, sunk as soon as the centres of the arches were removed, the 25th July, 1747, which accident caused the pier and two of the arches to be taken down and rebuilt, thereby preventing the bridge being opened for the public till the year 1750.

Blackfriars Bridge was not finished till 1770, being 20 years later than that of Westminster, so that even the benefit of the piles under the caissons does not appear to have enabled it to withstand the mining action of the currents on a gravel bottom. Neither will the Waterloo, the Southwark, or the new London Bridges be exempt from this casualty, if the foundations of the piers be not imbedded deep enough, beyond its influence, or that means be not taken to prevent the further progress of the action of the current on the bed of the river.

We may now inquire what are the means hitherto employed, or suggested to remedy the work of destruction now going on, already so effective on two bridges not yet one hundred years of age, while the age of similar structures elsewhere are meted by thousands of years!—the old London Bridge, with all its defects, had endured nine hundred years.

In regard to Westminster Bridge, which had no piling under the caisson, and under which the action of the current had formed a deep channel in the bed of the river, under several of its arches, on a level with, or lower than the bottom of, the caissons. It was determined to construct cofferdams round the several piers thus undermined, and then to drive piles all round the foundations, with the intention, no doubt, to keep the foundation from slipping, and to keep the soil or gravel from going from under the pier. But the remedy thus applied unfortunately only tended to increase the evil, inasmuch that, during the driving of the piles, the concussion given by the driving, as well as the grapplings and anchors used for this purpose in that part of the river, would facilitate and urge the already too prone disposition of the soil or gravel to fall into the depth of the channel, and be carried off by the current. And every pile thus driven, besides causing the removal of a large quantity of gravel from under and around the piers within the sphere of its action, would also lessen the passage for the water, and consequently increase the velocity of the current, which would be thus progressively increased; and its action in the work of undermining the pier would also go on in a proportional progression, till the cofferdam could be completed, which is not the work of a day, of a week, or of a month, whereas the action of the current is incessant and loses no time, but will increase in energy as the pile-driving proceeds; and if, when the cofferdam is closed, putting the foundation of the pier in apparent security, the current then being contracted into a more narrow space, will, as if in retaliation, act with so much the more energy in deepening the channel, and thus tend the more to undermine the piers, and even the very piles which were driven for to baffle its efforts. That this is the result, has been fully shown, and will at all times, under similar circumstances, be so, is evident from numerous examples which could be cited, if it were necessary; but those who will not believe what they see, cannot be expected to take for granted what they are told. What I have here endeavoured to explain has, I believe, taken place at Westminster Bridge; during the time the piling was being proceeded with, the piers under that operation sunk so considerably as to endanger the falling of some of the arches. It was then decided to apply centerings to prop up the arches,—thus one expedient invariably leads to another. Let us examine for an instant the consequence which may be expected from this new expedient. I have already ventured to affirm that, after all the piling they have applied, and if as many more were added, it would not give stability to the piers, but, by contracting the water-way, would render the destruction of the bridge, if possible, more certain. If, then, under that dilemma, being certain the piers will continue to descend, while the arches are by centres retained at their present elevation and position, is it not evident that the pier will be separated from the arch, and thus the bridge would become completely dislocated, *never again* to be re-united until the pier be secure, and until the arch be rebuilt?

What is now going on at Blackfriars Bridge? They are titing and tatting about the channel, under the bridge, and about the foundations of the piers, and after many weeks delay in searching out what might at once have been inferred, it has been discovered that the foundations of the piers are degraded, and the bridge consequently in a dangerous state; all this can be discovered by a superficial observer walking along the bridge, without either a diving-bell or a sounding-pole; the crushings and fractures, and variations of levels—taking place on the parapet from day to day, with a fearful rapidity—seem to announce the downfall of the bridge as near at hand, while nothing appears to be doing to prevent so deplorable a catastrophe, which, in case of the event taking place, will be anything but creditable to the country, and more especially to our engineering community.

It is in contemplation, say they, to stop the thoroughfare on the bridge, and to erect centres under the arches, as at Westminster Bridge; this will certainly be an interesting feature at the great Exhibition, to exhibit to the world, that after building costly, and what might well be deemed efficient bridges, that from unjustifiable parsimony, or neglect, we allow these bridges prematurely to perish! I have already said, and endeavoured to illustrate, what will be the result of piling and centering—it will aggravate the evil, and accelerate the destruction of the bridges to which it may be applied.—What then is to be done?

It is, in my humble opinion, simple, efficacious, expeditious, and of little cost, compared with other means that have been or may be suggested—that is, if not too late. For if the pier or piers of the Blackfriars Bridge be already very much degraded, there is no remedy but to demolish and rebuild the arches, and the pier or piers; but, if a few weeks ago (perhaps it is not yet too late), in place of wasting time in frivolous manœuvres, those charged with these matters had set to work in right earnest, with every means available, to fill up with rubble stone or hard brick the deepest part of the channel under the bridge, to bring it up to the general level of the bed of the river at that part, the same operation being continued throughout the entire transverse section of the river, above and below the bridge, for at least one hundred feet; then, I have no hesitation in saying, the bridge would have been preserved from further accident. Having been so well forewarned of the probability of such accidents occurring, it appears to me unaccountable that the state of the bed of the river has not been carefully watched, more especially near the bridges, and that any deviation from the proper levels should not have been at once corrected, by filling in with stone or brick rubbish.

And if it be desirable to secure the other bridges from similar accidents, that which I have now suggested is the safest, the surest, the cheapest, perhaps the only rational mode of attaining the end desired—reason, and practice by the first masters, confirm what I here advance. Smeaton employed this means to save the old London Bridge, in an emergency like that now occurring at Blackfriars Bridge, but he was imperative as to time, and by his desire the Corporation of London ordered a lot of houses to be pulled down, expressly to be thrown into the river: the bridge was at that time saved.

The engineer, Deschamp, having built a fine bridge of three or four arches over the Dordogne at Libourn in France. Before two years after its completion, the current had so lowered the bed of the river under the bridge, that the piles on which the piers are built were to a great extent laid bare, and the whole pier vibrated by the action of the current. To remedy the evil, he employed the means I have quoted, and succeeded. This incident led him to watch with particular attention another bridge of his construction, of nineteen arches, crossing a river 1600 feet wide (the Thames at London is, I think, 1200 only). Both these bridges of M. Deschamp's construction are built on a mud bottom, more than 60 feet deep. Notwithstanding this very precarious ground to build upon, his bridges have, by due attention, been preserved from injury, by employment of the means I have here suggested for the metropolitan bridges.

The examples I have cited are, I think, quite sufficient, in support of the explanation I have given in regard to the cause of such accident, and the means of preventing them. The remarks which have been made of late in several contemporary publications, on the state of the Blackfriars Bridge, have led me to the preceding considerations, which, with more leisure, might have been better arranged and more extended. The importance of the subject, nevertheless, however imperfectly here considered, will perhaps induce you, Mr. Editor, to receive, with your usual courtesy, these and any authentic information or well-intended suggestions on the subject.

London, Sept. 19*th*, 1850. WILLIAM STEWART.

GOETHE ON THE CATHEDRAL OF STRASBURG.

[Translated by J. L.]

"THE more I viewed the front of this edifice, the more my first impression was confirmed and developed, viz., that the sublime and the pleasing have been here completely blended. But as it is only possible to describe the impression made on us by that edifice, if we think of the combination of these two incompatible qualities, we become the more impressed with its great worth, and shall use every effort to express how such contradictory elements could ever harmoniously combine and penetrate each other.

Without considering at first the steeples, we shall speak of the front, which, in the shape of an erect oblong square, forcibly strikes our eyes. If we approach it at twilight, by moonshine, or in a starry night, when the single parts have become gradually indistinct and have at last disappeared, we perceive nothing but a colossal wall, the proportions of whose breadth and height are adequate and pleasing. If we view it by daylight, and abstract in our mind from its details, we perceive the front of an edifice which does not only close up its interior, but even hides many adjacent parts. The apertures of this huge surface point to the interior, its wants and contingencies—and according to this we may divide it into nine compartments. The great central porch, which is directed towards the nave of the edifice, first attracts our attention. On both sides are two minor ones, belonging to the aisles. Over the porch is the round window, which spreads over the church and its vaults a mysterious light. On the side of this appear two perpendicular large openings of an oblong square form, which bear a great contrast to the middle one, and seem to indicate that they belong to the base of the towering steeples. In the third story, three openings succeed each other, which serve for belfries and other ecclesiastical purposes. On the top the whole ends horizontally with the balustrade of the gallery, which serves in lieu of a cornice. The nine spaces just described are supported by four buttresses rising from the ground, which encompass them, and divide the front of the edifice into three large perpendicular sections. And as it cannot be denied, that the whole front possesses a fine proportion of breadth and height, these pillars also, as well as the gracile compartments between, add to the harmonious elegance of the detail.

But let us continue our abstractions, and fancy this whole wall without ornament and with solid buttresses, in it the needful apertures, but only so far as absolutely necessary; let us think all that in due proportion, then the whole would be still commanding and serious, but withal appear cheerless and cumbersome, and be wanting in art and ornamentation. Because an object of art whose whole is comprised within grand, simple, and harmonious parts cannot fail to produce a noble and worthy impression; but that very enjoyment which is produced by the pleasing, cannot arise but from a concordance of all detail duly developed. And it is in this way that the edifice satisfies us in the utmost possible degree, because we perceive all and every ornament completely in accordance with that part which it adorns; they are co-ordinate to it, and seem to come out from it. Such a variety affords always a great satisfaction, as it is derived from a sense of appropriation (*aus dem Gehörigen*), and thence satisfies our propensities for unity; and it is only in such cases that the execution of a work attains the pinnacle of art—perfection.

By such means it has been effected that a compact wall, a solid surface, which we view also as the basis of two heaven-reaching steeples, appears to the eye, albeit independent of itself, existing for itself; still, as something light and gracile, something which although a thousandfold broken through, bears the stamp of indestructible solidity. Such riddle is most happily solved. The openings of the wall, the solid spaces, the buttresses, have each its own character, arising from its individual destination; this goes down gradually to the minor compartments—thence everything is ornamented in a chaste manner, the great and small is in its right place, can be understood with ease, and thus the pleasing is manifested even in the huge. I point merely at the doors, which are sunk perspectively in the substance of the walls, ornamented *ad infinitum* on their pilasters and pointed arches; to the window and that artificial rose-form which arises from its circular shape; in fine, the profile of its bars, as well as at the slender reed-columns of the perpendicular compartments. May one fancy to himself the gradually receding pilasters, accompanied by slender, pointed arches; little structures, as it were, which, being destined for shrines of holy images, consist of equally uprising slender columns, ending in a sort of canopy; and thus, in fine, every frieze, moulding and finial is transformed into a cluster of flowers or bunch of leaves, or some other form of nature turned into the character of the rocky material. Every one may compare the building itself, or some designs of either the whole or its details, with what I have said, for the sake of judging and verifying my opinion. It might appear exaggerated, because I myself, although carried away at first by my admiration for this work, still required some time, until I became thoroughly imbued with its worth.

Brought up amongst cavillers at Gothic architecture, I cherished an aversion against those manifold, overloaded, confused, ornaments which, by their arbitrariness, rendered the character of a gloomy religion almost repulsive; and I became confirmed in this ill-will, as it were, merely works most deficient in spirit, on which neither a right proportion, nor any pure consequentiality was impressed, which came under my observation. In the Strasburg Cathedral, however, I thought to obtain a new revelation, as none of the above defects, but rather the reverse, were presented to me.

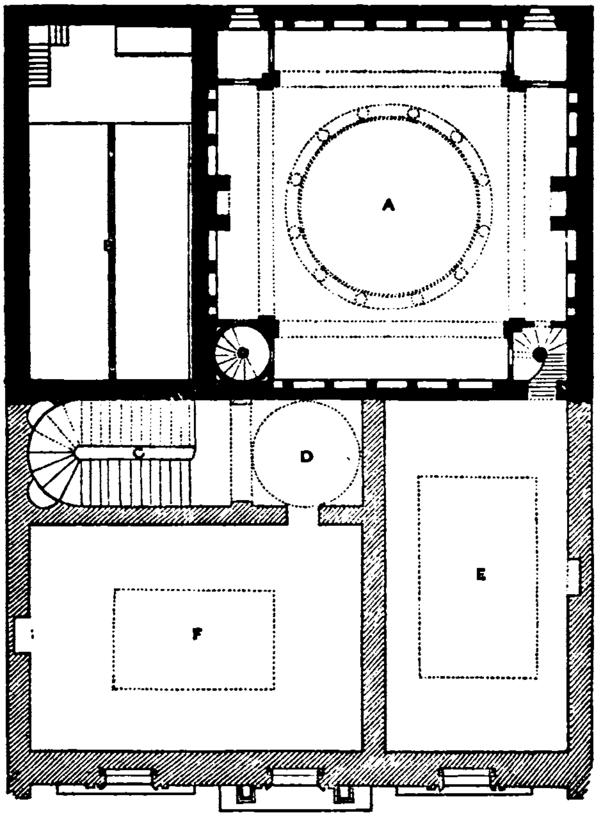
But the longer I continued to view and to consider, the merits above alluded to seemed to increase. I had already found out the right proportions of the major compartments, as senseful as rich an ornamentation, up to the minutest detail: now I began to comprehend the relation of these numerous ornaments to each other—the combination of so many single objects, although similar yet infinitely varying in form and particulars—from the saint to the monster—from the rose to the smallest leaflet. The more I observed, the more I found to admire; the more I mused, or wearied myself with drawing and measuring, the more I became enamoured of the work; so much so, that I devoted much time either in studying the present building, or in restoring on paper and in my mind, the much which is wanting and uncompleted, especially in the steeples.

And, as it was in an old German locality that I found this edifice reared, and in a truly German period of history so far progressed; and as the name of the builder on his modest cenotaph was also of German origin and sound, I dared, then, I say, called upon by the worth of the structure, to change the hitherto ill-famed appellation of Gothic architecture, and to vindicate the renown of *German* art-building for our nation."

THE PLYMOUTH PUBLIC AND COTTONIAN LIBRARY.

Messrs. Wightwick and Damout, Architects.

(*With an Elevation and Plan.*)



A, Library; B, Porter's Apartment; C, Staircase; D, Lobby, E, Law Library; F, Cottonian Library.

We give this month an elevation of the new building which is now being erected, in addition to the existing Public Library of Plymouth, for the reception of the munificent bequest which has been made by William Cotton, Esq., for the benefit of art and literature in the west of England; and certainly Plymouth has just reason to be proud of the good will of such a donor, and of the riches he has consigned to her possession. To meet the singular liberality of Mr. Cotton, the shareholders of the old library and the public in general have come forward in a manner which does them credit, to provide a fitting casket for the reception of the gems consigned to them: and a building has been designed, which, though necessarily simple in its general form, will be highly ornate in its features. It is already commenced, and is expected to be finished about May next. The ground-floor will be devoted to the common entrance, and to the reading and committee-rooms of the Public Library; also to the staircase exclusively belonging to the Cottonian apartment, which will occupy the chief portion of the upper floor. Of this floor we give a plan. The rooms are to be lighted by handsome lantern lights, constructed with every regard to the true effect of the pictures, drawings, and articles of *vertu* which will enrich their walls.

The old building was erected in the year 1812, from designs by the late J. Foulston, architect, and presented a recessed front of severely Greek character, after the fashion of the Monument of Thrasyllus at Athens. The present front is brought forward as far as permissible by the town authorities, and is in the Græco-Italian style. The architects are Messrs. Wightwick and Damout, of Plymouth, who have erected many public structures in the west of England, and the one now represented is not among the least creditable. The material is stone; and though the building is not of great dimensions, a character of respectability is given to it by the large size of the details, Messrs. Wightwick and Damout having carefully treated the door and windows, which are few in number, but of large size, well grouped together, and highly ornamented. On the ground-floor, it will be seen, these openings occupy much of the wall-space; and though decorated, the degree of ornament is less than on the first floor, where the three windows are each of single lights and smaller dimensions. These windows are carried up in the line of composition from the middle light of the lower windows and from the door, so as to secure harmony and uniformity in the design. The treatment of the cornice, balustrades, &c. likewise deserves notice, and contributes to the effect of the building. The various points of composition are well balanced; and the whole shows evidence of artistic skill and power of composition and combination.

Mr. Cotton's donation consists of various ranges of bookcases of amboyna wood, with plate glass fronts, containing many hundred volumes of books in the various branches of literature; a splendid and unique series of 4700 prints, engraved by the best artists from paintings by the most celebrated masters; a valuable collection of about 250 original drawings, by the old masters, in the most perfect state of preservation; a considerable number of paintings and framed drawings and engravings, of rarity and value; several illuminated MSS. of much beauty and elegance; some magnificent cinq-cento bronzes, terra-cottas, models in cork, and carvings in box wood, cabinets, carved furniture, &c.; many magnificent china vases and beakers, casts, &c.

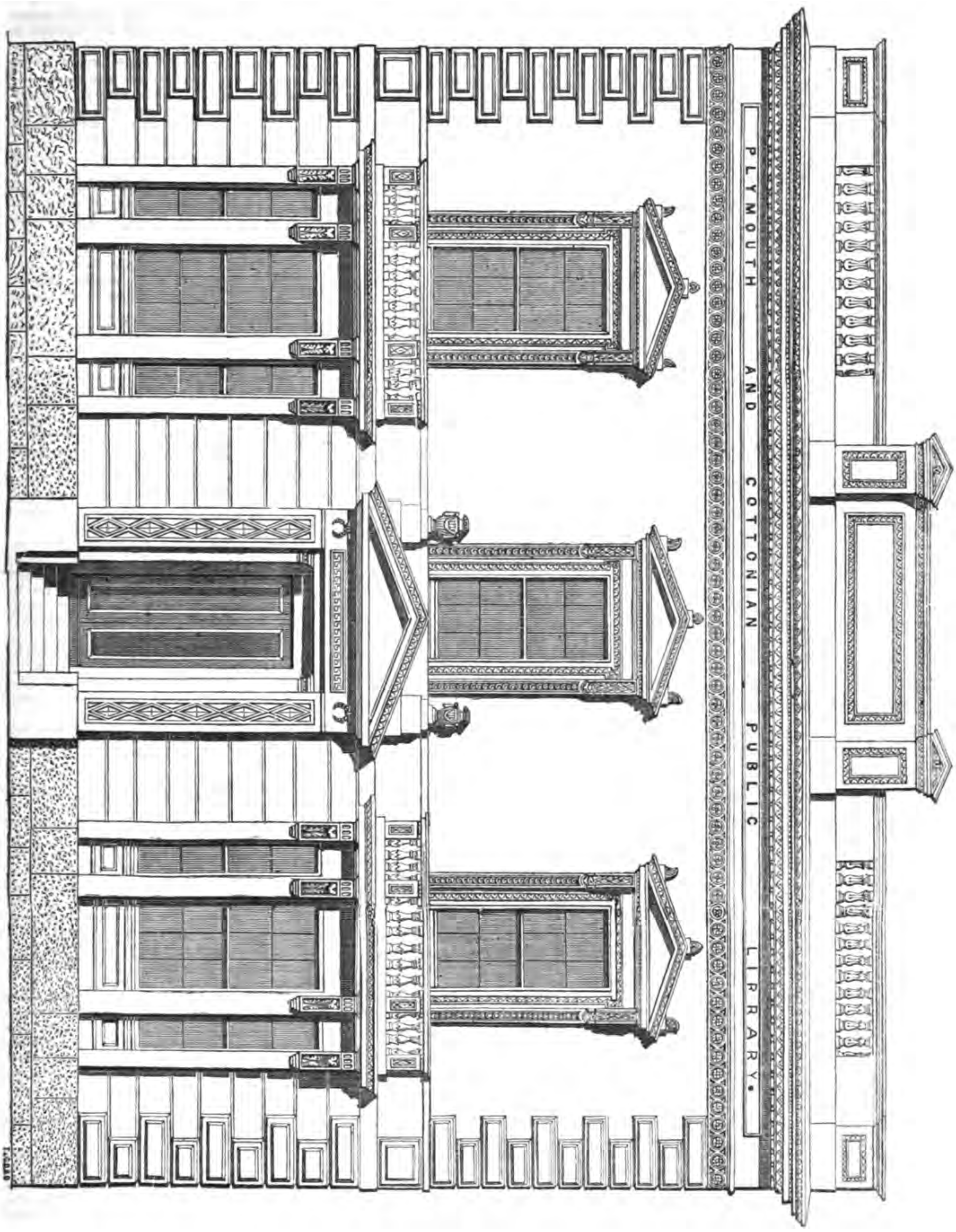
The collection of books contains many specimens of early Topography; works on the Fine Arts and Antiquities; Greek and Latin Classics; the most celebrated French, Italian, and Spanish authors; the English poets, &c.

The collection of original drawings by the old masters comprises amongst many others, some splendid examples by Zuccharelli, Guercino, Agostino Caracci, Claude, Ruysdael, Van der Velde, Berchem, Van Goyen, Van der Meer, Rousseau, Chatelain, Breughel, Loutherburg, Domenichino, Carlo Maratti, Poussin, Boudon, Le Brun, Rubens, Vandyke, Verdier, Watteau, Cipriani, Ruysbach, Leonardo da Vinci, Andrea del Sarto, Bassano, Mola, Holbein, De la Bella, Callot, Boucher, Rembrandt, Inigo Jones, Barlowe, Seymour, Deacon, Worlidge, Richardson, Thornhill, Cosway, Paul Sandby, Watts, Marlow, Cattermole, Turner of Oxford, Denning, Purser, Wilson, Lambert, Wootton, Isman, Cooper, De la Motte, Dallaway, &c. &c. Among the bronzes are Lorenzo de Medici, after Michael Angelo; History and Eloquence, after Algarchi; Samson and the Lion, by Benvenuto Cellini, (from the Pesaro Collection); Antinous, &c. &c.

Among the Models are a Philosopher reading, by Michael Ruysbach; Farnese Flora and Ceres, by Coade; Santa Babrina, by Bernini; Santa Susanna; Gladiator; Venus and Mercury, by Pigalli; Jupiter and Mercury, in wax, by Gosset; Shakspeare, Hindoo Idols, &c.; models of houses and baths at Pompeii, wood-carvings of Silenus, &c.

The paintings contain examples by Sir Joshua Reynolds, and many other distinguished masters.

Altogether this collection supplies great artistic resources for Plymouth and its neighbourhood, which boast the birth-places of Reynolds and Haydon. It is to be hoped application will be made to the government for a collection of casts, and that it will be answered with the same success as in the case of the Salford Museum and Library.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COMPETITION FOR THE BUILDING OF THE RHINE BRIDGE, NEAR COLOGNE.

The above certainly is a work which, when completed, will reflect credit on our age, as since the times of Drusus no bridge ever existed on this part of the Rhine. The competition drawings sent in amount to the large number of 163; amongst them 25 are from England. It cannot, however, be denied, that many of them are quite without any practical value. There are competent persons who also think that the small prize of 250 Frederic d'ors (of about 15*s.* each), may not have been sufficient for men of real ability to come forward in the competition. Still, amongst the plans from England, there may be several whose authors were rather prompted by ambitious motives than those of mere lucre. Some of the drawings attract notice by the splendid way in which they are ornamented. In a few cases there are special landscapes and views added to the plans, which could not have been drawn but by some professional painter of views. Some few are also framed and glazed, but the large size of the panes has occasioned their breaking during the transport. One of the competitors has specially come over to Germany, and has been presented to, and has dined with, the King of Prussia. It is, however, impossible to form now even an approximate idea, in how far this competition might have been the means to prepare the execution of a work whose estimated cost of *one and a half million* of thalers proves that even the mechanical means and contrivances of Germany will have to be *strained* for its ultimate completion.

L.

REVIEWS.

On the Strength of Materials, containing various original and useful formulæ, specially applied to Tubular Bridges, Wrought-iron and Cast-iron Beams, &c. By Thomas Tate, Author of the 'Principles of the Differential and Integral Calculus, Factorial Analysis,' &c. London: printed for Longman, 1850. 8vo., pp. 96.

When doctors disagree, who shall decide? Here is Mr. Tate asserting that the total breaking weight of the Conway Tubular Bridge is 2013 tons; while Mr. Hodgkinson computes the same quantity as low as 1084 tons—just about half!

Before inquiring which computation is nearest to the truth, let us explain that the difference of the methods by which such very different results have been arrived at is mainly this: Mr. Hodgkinson makes deductions from his own experiments, Mr. Tate from those of Mr. Fairbairn. The former found, from experiments on the direct longitudinal compression of wrought-iron tubes such as were to compose the cells of the top of the Conway Bridge, that eight tons per square inch was the utmost force which they could be relied upon to securely resist, and 12 tons per square inch to be their crushing force. He then assumes (Report of Iron Commission, p. 165) the material of which the bridge is made to be perfectly elastic; and when that is the case, the neutral line may be shown to be in the centre of gravity of the sections, the areas of the sections of tension and compression being inversely as the distances of the centres of gravity of those sections from the neutral line. He takes into account also the strength of the vertical sides of the bridge, of the angle-irons, &c. He finds the numerical values determining the position of the neutral line passing through the centre of gravity, and then shows that eight tons per square inch at the top of the tube (which he deems the limit of safety) corresponds to a load at the centre of the beam, which amounts, including its own weight, to 1084 tons, as above stated.

This is one method. The other likewise assumes that the elastic forces are proportional to the extension and compression respectively, and that the neutral axis coincides with a line passing through the centre of gravity of the section. Certain rules are laid down respecting the relative strength of *beams similarly proportioned.* (By the by, though Mr. Tate seems to imagine this method of treating the subject new, it has been employed in the pages of this *Journal*, and is also constantly referred to by Mr. Hodgkinson). Then an experiment on the "model tube," of 80 feet long, in which the breaking weight was stated at 89·15 tons, is taken as the basis of calculation; and assuming the Conway Bridge to be similarly proportioned to the model, its strength is deduced to be 2013 tons.

Something is necessary to be said respecting the accuracy of this celebrated experiment on the "model tube." This tube was broken several times in succession by the rending of the bottom plates, which were each time repaired, and increased in strength until at last the tube broke by crushing of its top. In the "Iron Commission" Report, p. 159, Mr. Hodgkinson gives the experiments in which the breaking weight was successively increased up to 66 tons, and there stops short, adding significantly, "There was a subsequent experiment on the same tube, *which is not here given, as I conceive there must be some error in it.*" What error? Did Mr. Hodgkinson imagine that the breaking weight was erroneously set down? or that undue precaution was taken in selecting the very best iron, and so preparing the experiment, that its success was rather apparent than real? We are not informed for what reason this experiment is rejected; we are simply told that it is not trustworthy; and, considering what an important bearing this very experiment has on the whole question, and on the public safety, it is reasonable to complain that so grave a charge is not circumstantially supported.

It will be seen from the above account of Mr. Tate's method, that the accuracy of his calculation of the strength of the Conway Bridge depends ultimately on the accuracy of his results deduced from the data of the "model tube." On this subject he makes the following observations (p. 59):—

"In this model beam the principle of crumpling seems to be eliminated by the thickness given to the plates, by the combination of the cells, and by *strong* angle-iron used in connecting the plates. This is rendered apparent from the fact that the top area is nearly equal to the bottom one, when the equality to resistance is attained. Hence the model tubular beam may be regarded as a common beam, obeying the ordinary laws of compression and extension when subjected to transverse strain. The assumption, therefore, that the Conway Tube will have the same resistance to compression as the thin rectangular cells experimented upon by Mr. Hodgkinson is erroneous in principle; and this is rendered still more apparent from the calculations on the model tube given in Art. 65, where the resistance per square inch to compression is found to be about 18 tons, in the place of 8 tons, which Mr. Hodgkinson assigns to it."

The above method of establishing the original hypotheses respecting the law of elasticity is altogether inconclusive. Those hypotheses lead to a result which nearly accords with fact—namely, the approximate equality of the areas of the bottom and top of the tube when they are equally strong to resist tension and compression respectively. From this fact, Mr. Tate argues back that the hypothesis—not may—but must be true. The fact in question is, however, consistent with a thousand other hypotheses which might be contrived and combined so as to lead up to it. This mode of discussing the question is, in fact, the old illogical error of confounding a direct proposition with its converse—the inferring from "all mutton is meat," that all meat is mutton. T asks T', Do you admit so and so to be fact? Yes. Then my propositions are true, for they lead to it. This mode of discussion may be termed a *Tate-a-Tate.*

In order that the propositions may be certainly correct, every legitimate consequence of them must be consistent with correctly observed results. But, in truth, they lead to a result which, to any one moderately well acquainted with the laws of elasticity of iron, would instantly condemn them. In Art. 65, referred to in the above quotation, the *tension* per square inch of the bottom of the model tube is found to be 21 tons. Now, it is known, from frequent and indisputable experiment, that the elasticity of wrought-iron is almost entirely destroyed by a far less force. In the Report on Iron Structures, page 178, Mr. Hodgkinson states, that it appears "from the results of several experiments that wrought-iron strained by *tension* beyond 15 tons per square inch, or by *compression* beyond 12 tons per square inch, would be destroyed for all practical purposes."

It is difficult to ascertain the utmost extent to which wrought-iron can be stretched before breaking, because its *ductility* permits it to be drawn out almost to any degree—into a wire, in fact. Up to a strain of about 12 tons per square inch the extension increases almost precisely in proportion to the extending force. Beyond that strain the iron begins to be drawn out very rapidly. Consequently, the ratio of the weight to the extension is at first constant, but decreases very greatly after the strain exceeds the limit just indicated. For instance, in the Report of the Iron Commission, p. 47, the stretching weight (in pounds per square inch) of a wrought-iron bar 10 feet long, is found to be to the extension (in inches) in the mean ratio 232223 : 1, which ratio preserves nearly exact uniformity for the first 12 or 13 tons. For a single additional ton per square inch the ratio is reduced to less than *one-half*—namely, 113228 : 1, and one ton more reduces the ratio to 67363 : 1, which is between *one-third* and *one-fourth* the original value. When the strain is about

21 tons per square inch, its ratio to the extension is 16139 : 1, which is between one-fourteenth and one-fifteenth of the original value.

Mr. Tate assumes the extension to be always in the same constant ratio to the tension; and the latter he takes to be 21 tons per square inch at the bottom of the model tube. It appears, then, that he assumes the ratio at *more than fourteen times its real value!*

This is, of course, decisive of the character of his assumption as to "perfect elasticity." But the nature of the error may be even more palpably shown. If h be the distance from the neutral axis to the under edge of the beam, and a the ratio which the tension per square inch bears to the extension of a unit of length of metal, and ρ be the radius of curvature, we know, by the ordinary laws of simple beams, which Mr. Tate applies here, that the tension per square inch of the under side of the beam is

$$\frac{ah}{\rho}.$$

The quantity h Mr. Tate makes equal to 25·55, and the tension = 21 tons = 47040 lb. Also we have stated that the corresponding ratio of the tension to the extension of a bar 10 feet or 120 inches long, is 16139 : 1, consequently, $a = 16139 \times 120 = 1936680$. Therefore, the equation follows

$$47040 = \frac{25{\cdot}55 \times 1936680}{\rho};$$

$$\text{or,} \quad \rho = \frac{49482174}{47040}.$$

According to the hypotheses of the work before us, the constant moduli of extension and compression are different; but the equation to the curve of deflection will be of the same form as the ordinary elastic curve. Consequently, by known principles,

$$f = \frac{l^2}{12\rho};$$

where f is the central deflection and l the length of the beam between supports. Taking the value of ρ determined above, and $l = 75$ feet $= 900$ inches,

$$f = \frac{810000 \times 47040}{12 \times 49482174} = 64{\cdot}1 \text{ inches.}$$

That is, the deflection is more than *five feet four inches*. Comparing this rather startling result with Mr. Fairbairn's statement to the Iron Commission of the observed deflection (which in the Report, p. 410, he says was 4·88 inches), we find that Mr. Tate's hypotheses make the deflection *between thirteen and fourteen times its observed amount.*

In addition to the above evidence, that the tension and compression of the lower and upper parts of the tube could not be what Mr. Tate, calculates them to be, if the beam retained perfect elasticity, we have strong corroborative testimony of authorities on this very point. We have already quoted the opinion of Mr. Hodgkinson, that the metal would be destroyed by far less strain. Mr. Edwin Clark, also, in his evidence before the Iron Commission (Report, p. 361), observes:—

"We looked upon 12 tons to the inch to be as much as we could safely subject wrought-iron to as regards compression. We took the resistance to compression to wrought-iron as about 10 tons per square inch. We found, generally speaking, when you get up to 10 tons to the inch, most iron begins then to be perceptibly altered in shape."

Again, page 362, he says:—

"We were therefore limited to 12 tons to the inch, but as we were not going anywhere near such a limit as that, nor even half of it, it hardly came into play. If we made a thin cell it puckered; if we kept the same dimensions, and kept making the plates thicker, we avoided the puckering till at last we arrived at the thickness at which iron no longer puckers, but sustains nearly the whole strain of 12 tons per inch."

It was a matter of difficulty then, and of rare occurrence, to carry the strain up to 12 tons, whereas Mr. Tate computes it at one half as much more.

There is other evidence that the hypothesis of constant proportion of the elastic forces to the corresponding extension and compression is frequently quite remote from the truth. If the hypothesis were true, the deflection of all the experimental tubes should be proportional to the deflecting pressure. This, however, is found not to be the case. We here give a few of the deflecting weights, and corresponding deflections, of various rectangular tubes experimented upon by Mr. Hodgkinson (Iron Commission Report, pp. 125 *et seq.*), together with what the deflection would be if proportional to the weight. All the columns of the following table, except the last, are taken from the Report.

Length of Tube.		Depth.	Breadth.	Weight on the tube in the middle.	Observed deflection.	Deflection if proportional to the weight.
ft.	in.	in.	in.	lb.		
4	2½	3	1·95	448	·035	
				1344	·150	·105
				2240	·345	·175
				2464	·435	·1925
8	2	6	3·9	2136	·12	
				6616	·42	·37
				8296	·73	·46
				8856	·81	·49
31	6	24	15 5	11,369	·40	
				51,157	2·5	1·8
31	6	23·75	15·5	89,685	1·35	
				100,885	1·67	1·51
				120,485	2·69	1·81
				126,085	3·03	1·89
				128,885	3·48	1·94
31	6	23·75	15·75	33,685	·85	
				67,285	2·	1·69
				72,885	2·25	1·83
31	6	24	16	20,632	·53	
				40,685	1·20	1·04
				50,730	1·66	1·30
				57,414	2·32	1·47

It appears manifest from a mere inspection of the preceding table, that Mr. Tate's assumption of the law of elasticity is not in accordance with a large number of observed facts. It is very important, however, to observe that whatever inaccuracies may be involved in the law assumed by him, are quite inadequate to explain the enormous discrepancy between the deflection of the model tube as observed and as computed. The discrepancy may arise in one of three ways—from inaccuracy of theory, from what Mr. Hodgkinson terms "some error" in the data of the experiment itself, or from combination of mistakes of both kinds. A very careful examination of the question has satisfied us that Mr. Hodgkinson's surmise is indisputably correct, and that the principal source of error is in the data of the experiment itself.

Without any doubtful assumption of the law of elasticity, we ascertain with sufficient accuracy the limits within which the tension at the bottom of the tube *certainly must* lie. We observe that the compression of the top of the tube is supplied partly by the plates forming its upper side, and partly by plates lower down. Consequently the "centre of compression" is somewhere below the top; similarly, the "centre of tension" is somewhere above the bottom. The moment of the "couple," of which the distance between these two centres is the arm, is equal to the moment of the pressure of the beam on its abutment or fulcrum. The greater the "arm" the less *cæteris paribus* are the equal forces of compression and tension. Therefore taking the arm equal to the whole depth of the beam, we make the tension less than it can possibly be. Supposing all the tension to be at the bottom of the tube, let t be the tension in tons per square inch. Take the area subject to this tension at 19 square inches, deducting 3½ inches, the area of the rivet holes. Also the depth of the tube is 54 inches, the moment of the tension is therefore $54 \times 19 \cdot t$. The pressure on the fulcrum is half 89·15 tons, the breaking weight, and the distance of the fulcrum is 450 inches. Therefore,

$$54 \times 19 \cdot t \text{ must he greater than } 89{\cdot}15 \times 225,$$

or the tension must exceed 19½ tons per square inch; and Mr. Tate makes it 21 tons per square inch, a closely corresponding result. The result is not materially affected if we take into account the area of the vertical sides of the tube.

The deflection above computed is not that which would actually occur in a tube of the dimensions of the model strained to 21 tons per square inch on its under side; but merely the result of Mr. Tate's hypotheses. In the investigation of the ordinary elastic curve a certain quantity is neglected as small, which would not be inconsiderable in the case before us. Also the expression for the radius of curvature is in reality dependent on the varying ratio of the tension to the extension. But that the *real* deflection of a tube of the given dimensions, subject to the given weight, would be much larger than the deflection given in the published accounts, appears certain from this consideration: the strain would be more than 19½ tons at the centre; and it would be larger for a considerable distance on either side the centre; consequently, the extension of the material would be great, and therefore the radius of curvature small, for a large portion of the curve; whereas the published deflection would make the radius everywhere large.

As it appears then from the evidence of practical men, and also from the computation above, that it is quite impossible that the tube could sustain anything like the computed tension, we are driven to the conclusion that the data themselves are erroneous.

We refrain from comment on this most disagreeable conclusion, for the charge which it involves is of too serious a nature to be disposed of satisfactorily in an incidental manner. The public were indubitably called upon to place confidence in the sufficiency in the tubular bridges by the evidence of this very experiment, of which the particulars, it is but too evident, have been wrongly stated. We are anxious to believe that the exaggeration of the strength of the model tube was unintentional, that it did not arise from an ignorance of the power of mathematics to detect the fallacy, or a futile hope to escape that irresistible cross-examination.

Happily we have the investigation of Mr. Hodgkinson to give confidence as to the strength of the actual Conway tube. Mr, Tate objects that whereas in the tubular bridge the upper side of the cells is more compressed than their lower part, that investigation proceeds on deductions from experiments in the direct longitudinal compression of cells by a pressure uniformly distributed over their ends. But the weight of the objection is small when it is considered that the inequality of the pressure is small on account of the comparatively great distance of the neutral axis. The general character of Mr. Hodgkinson's investigation appears to be that of a careful and moderate estimate of the strength of the Conway Bridge, which, if the complexity of the subject do not permit of its perfect accuracy, is far, very far, more worthy of confidence than any deductions from the Millwall "model tube."

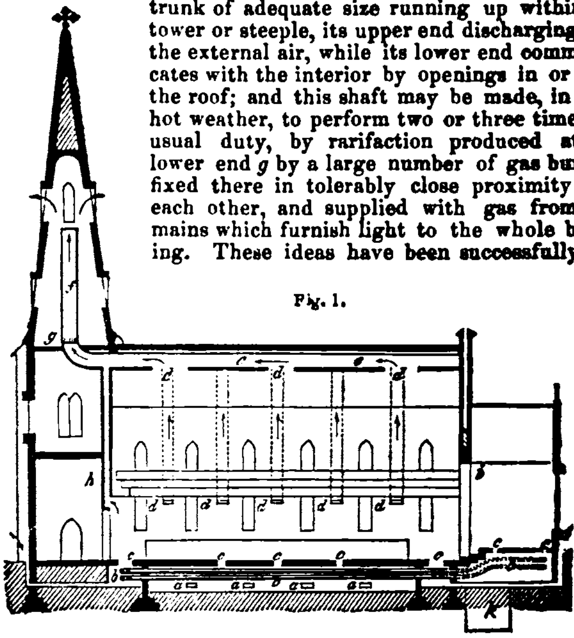
Useful Hints on Ventilation. By W. Walker, Engineer. Manchester: Parkes. 1850.

We are glad to see from the numerous and cheap works which issue from the press, that ventilation is attracting its fair share of public attention, and we therefore welcome the present contribution, as no doubt our readers will; and although ventilation is now supposed to be well enough understood, they will no doubt read with satisfaction the extracts we here give, illustrative of Mr. Walker's practical treatment of the subject.

In reference to steam agency Mr. Walker observes:—

"However useful steam agency, as applied to ventilating purposes, may be in factories or buildings connected with them, and in theatres or other places liable to great and sudden influx or efflux of persons; and well as it has been found to answer in its application to other buildings, such as club-houses, banks, collegiate institutions, and hospitals, in which manifest advantages have been derived from its employment; there will still be great numbers and many classes of edifices in which it would be, from various causes, inadmissible. Churches, chapels, and houses for worship, may be enumerated under this head—the numbers contained within their walls being, on the whole, tolerably constant, and not liable to very sudden fluctuations; but especially from the circumstance that they are seldom used more than two days in the week, with intervals of two or three days between; and when used it is only for two hours consecutively, with intervals of two or three hours between. With such proper quantity and sizes of ingress and egress flues as can readily be obtained in the thick walls and piers of such edifices (if planned prior to their construction), this short period of occupation will not permit their atmosphere to become very highly charged with impurities, while the intervals between the services will be found sufficient for an entire change of the whole atmosphere left in them at the close of each service, without resorting to mechanical means. In churches with lofty open roofs, of the mediæval or early-English construction, without galleries, the total cubic space bears so large a proportion to that portion of it occupied at the floor level by the congregation, that scarcely any injurious vitiation of the entire atmospheric contents can take place during the short period of occupation, provided moderate preparations have been made for ingress and egress. Hence, very sudden and powerful ventilation is scarcely required in such churches, and the purification of their atmosphere may safely be left to the spontaneous action of those preparations; but on special occasions, and in hot weather, the action of the fresh-air flues may be accelerated by the exhausting power of a shaft or trunk of adequate size running up within the tower or steeple, its upper end discharging into the external air, while its lower end communicates with the interior by openings in or near the roof; and this shaft may be made, in very hot weather, to perform two or three times its usual duty, by rarifaction produced at its lower end *g* by a large number of gas burners fixed there in tolerably close proximity with each other, and supplied with gas from the mains which furnish light to the whole building. These ideas have been successfully carried out in numerous instances and in large buildings. The whole process recommended for such a building will be better understood by a reference to the upper portion of figure 1, which represents a section of a church ventilated in this manner, *a a*, are openings all round the church for admission of fresh air; *b b*, hot-water pipes, over which it is made to pass on its way to the gratings *c c*; *d d*, are openings, by which the vitiated air enters a horizontal trunk *e*, from the end of which rises the shaft *f*, with a collection *g*, of gas-jets in the bottom of it; *h i*, is the gallery-line, and *k*, an excavated room for the boiler, the floor of which should be five feet below the floor-line of the church.

Fig. 1.



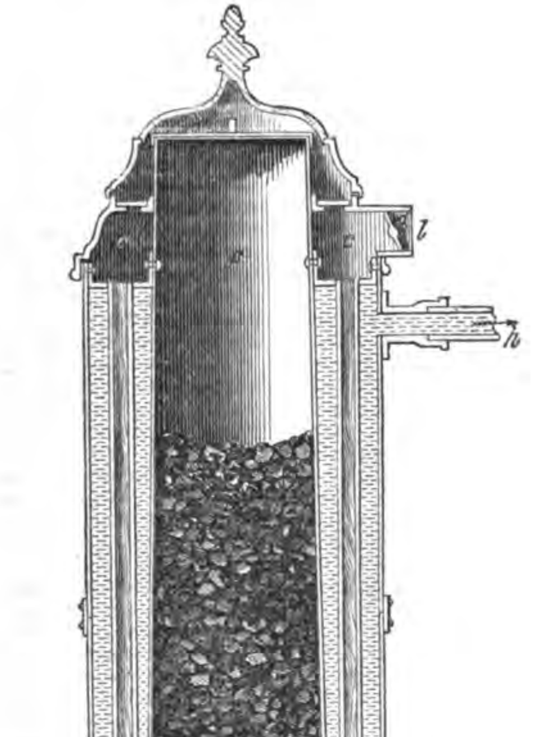
"By simply turning the cock in the gas pipe which supplies the jets, the rarefaction in the shaft, and, consequently, the velocity and quantity of the air passed through the church, may be controlled with tolerable accuracy, and instantly proportioned to any greater or smaller number of persons assembled. The cost of piping and cock for bringing the gas to the jets has been found to be but trifling; and as they need only be lighted during the time the church is occupied for worship, which is seldom of longer duration than two hours and a-half, the consumption of gas is not very great, and amply compensated by the beneficial result obtained.

"The means most proper to be adopted for the plentiful supply of fresh air in the low-roofed, galleried, and crowded meeting-house, will be found to consist in abundance of fresh-air openings all round under the windows, communicating by brick flues with the lower part of the spaces under the aisles and seats in which the hot-water pipes that are to warm the air should be fixed. Fresh-air flues should be constructed in all the piers between the windows, running as high as the gallery to supply it with fresh warmed air. A vitiated air-flue should also commence in each pier under the gallery (in order to give free egress to that which would otherwise be intercepted and detained under the gallery), and pass up into a horizontal trunk, running over the roof, along each side, into the foot of the upright shaft below the gas-jets, as before explained. Openings should also be left in the roof, communicating with these horizontal trunks, to carry off the bad and heated air over the galleries. Hot water pipes should be conveyed along the side-walls, under the floor, so as to warm the air that passes up within the piers into the gallery.

"The leading points to be observed in such a case are delineated in the lower part of fig. 1, below the line *h i*.

"A much larger provision should be made for supplying fresh air to such a house for worship, or other galleried building, than in one which has no gallery, and which possesses the advantage of an open roof; and those who would object to the copious measures here recommended, as unnecessary, should well consider the following facts and calculations. A chapel or meeting-house with large galleries nearly all round, capable of accommodating on special occasions 2000 persons, is frequently made about 75 feet square, and 25 feet average height, giving a total cubic content of rather more than 140,000 feet. Now the authorities, from Tredgold to Reid who have written on the subject of the quantity of fresh air, required per minute by each individual, to replace that which such individual has rendered unfit for respiration, vary in their conclusions from 3½ to 10 cubic feet; and if seven cubic feet be assumed to be the proper quantity, an allowance near the average of their scientific opinions will be given. The total quantity required, therefore, on this low standard in such a building, to maintain its atmosphere in a state of purity when filled, will be (2000 × 7 =) 14,000 cubic feet every minute, and a like quantity of vitiated air must be carried off in the same time. The atmosphere of the building will therefore require to be completely changed or renewed (140,000 ÷ 14,000 = 10) *once in every ten minutes.* Let it now be supposed that the unusual provision of 16 openings has been made all round the building, for fresh air, each opening measuring 18 inches by 6 inches. Deducting one-third of the area for impediment caused by gratings, will allow to each opening a clear area of half a superficial foot, and the aggregate area of all the openings will be eight feet. Now, to supply the required quantity of air (14,000 cubic feet) in the given time (one minute) through those openings, the air must pass through them all at the velocity of (14,000 ÷ 8 =) 1750 feet per minute, or more than twenty miles per hour; which it will not do, especially on a calm day in hot weather, *when ventilation is most needed,* without the aid of some powerful stimulus; and if such artificial impulse be wanting, those openings will, under the circumstances, be quite insufficient to prevent the rapid deterioration of the atmosphere within, and ought, therefore, to be considerably enlarged. The bad effects of the usual way of obtaining a partial supply of air in such a case by opening the windows, have been already commented on.

Fig. 2.



a, Fire-box; *b*, Ash-box; *c*, Smoke-box; *d*, Fire-bars; *e*, Smoke-tubes; *f*, Fuel-box; *g*, Damper; *h*, Flow or steam-pipe; *i*, Return or condensation pipe; *j*, Ash-box door; *k*, Fire-door; *l*, Smoke-pipe.

"Take another example from a large Gothic church, with galleries, and lofty side aisles and nave, in the neighbourhood where this is written; measuring 80 feet by 65 feet, with a roof approaching to flatness, about 30 feet in average height. This church has often contained 1800 persons; its cubic contents being 156,000 feet, and the requirement of air, allowing, as before, seven feet per minute to each person (1800 × 7 =) 12,600 feet. The time in which the whole atmosphere of this church would, when containing its full complement of persons, require to be changed, is (156,000 ÷ 12,600 =) 12½ minutes; and large openings will obviously be required to pass the quantity in the time.

"These figures will suffice to show the necessity for a very much larger provision for ventilation than has been customary in buildings containing galleries, in which the cubic contents bear a small proportion to the numbers assembled."

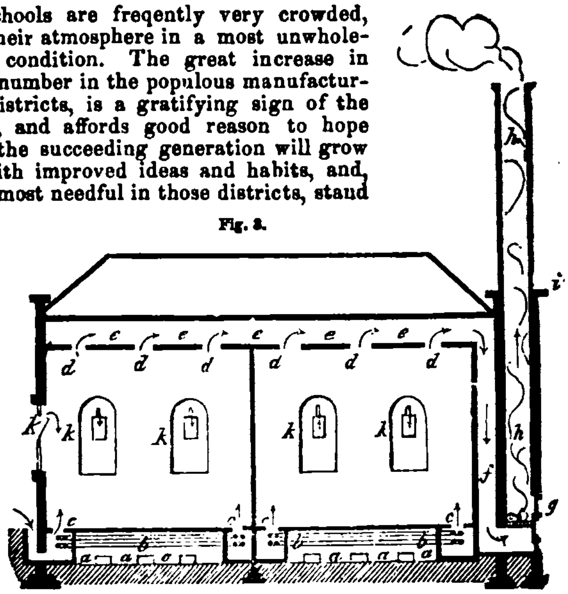
"The management of the warming of a church being a matter frequently entrusted to a sexton or verger charged with other duties, which necessitate his making a clean appearance, and demand his exclusive attention during the service, it is a matter of some importance where hot-water apparatus are used, to adopt such form of boiler as will require the smallest possible attention. The kind shown in fig. 2 in the annexed section, will be found to fulfil this requirement; many large churches having been kept by it at a uniform temperature with only three attendances in twenty-four hours. This sort of boiler will be found very desirable in many other buildings besides churches. They are to be filled to the top with coke broken into small pieces, which falls on the fire as required. A very useful kind of Arnott stove has been largely adopted on the same principle."

The stove here described appears to us a very simple arrangement for effecting the purposes desired, and to be well worthy of adoption.

In the whole range of ventilation there is, perhaps, nothing so much neglected as the ventilation of schools; and as it is most desirable public attention should be turned to the subject, we most willingly give room to Mr. Walker's statement of his views on the subject:—

"Schools are freqently very crowded, and their atmosphere in a most unwholesome condition. The great increase in their number in the populous manufacturing districts, is a gratifying sign of the times, and affords good reason to hope that the succeeding generation will grow up with improved ideas and habits, and, as is most needful in those districts, stand some degrees higher than their predecessors in the scale of civilisation.

Fig. 3.



"Fig. 3 is a section representing a boys' and girls' school ventilated (except as regards the windows) in a satisfactory manner; *a a* are the fresh-air openings; *b b*, pipes for heating; *c c*, gratings for entrance of fresh warmed air; *d d*, openings for foul air, leading into a trunk *e*, whence it is drawn down the shaft *f* by the rarifying-furnace *g*, whence it is discharged up the shaft *h* into the atmosphere.

"This arrangement of a rarified shaft, continued down to the ground for the purpose of obtaining a quick draught by a heated column, and requiring a down shaft to connect the ventilating trunk, from the top of the building, with its lower end, so that the foul air may enter it below the fire, is the same that has been adopted, at very great cost, by Dr. Reid, in the new Houses of Parliament. There is a complexity and expense about this arrangement which would seem to be needless. The drawing down to the ground-level of the whole of the vitiated air of the building, and then sending it up again; the cost of connecting the main down-shaft with the up-shaft, which circumstances may require to be at a considerable distance; and the trouble of forming air-tight connecting-flues to convey the vitiated air from numerous rooms to one main down-shaft, to say nothing of the double space and materials occupied by the two shafts, would render this plan, in numerous cases, impracticable. To overcome some of these difficulties, the fire has, in many cases, been provided for at the roof-level (*i* fig. 3), thus relinquishing the down-shaft and the lower part of the up-shaft, and so far has been an improvement; but in many cases the trouble of carrying up fuel and ascending to attend to the fire was too great, and the ventilation was, therefore, uncertain. The best mode of effecting forcible ventilation by a shaft doubtless is, to adopt the last-named arrangement; substituting gas rarifiers for a furnace, as shown in the church. (Fig. 1.) By bringing the pipe which supplies gas to the burners to some accessible point near the ground-floor, with a stop-cock at that point, the handle of which should work in a graduated quadrant, the ventilation can be regulated from below with great precision.

"Window-ventilation of a kind very frequently adopted in churches and schools, has been introduced into this figure (*k* fig. 3), not with a view to represent it as part of Dr. Reid's system, but to illustrate its bad effects, either where it is the sole provision made, or where it is used in combination with a better process. If it be the sole provision made, and the room be heated by a fire-place or stove, to 60°, a downward rush of air at 10° (should that low temperature happen to prevail outside at the time), will play upon the heads of those near it. If it be in force, as in the figure, simultaneously with proper means of introducing fresh warmed air, its force will be modified, and partially deflected upwards, towards the egress openings; but whatever cold air thus enters, is so much deducted from that which ought to have entered warmed, through the proper channel *c*."

We may observe, that Mr. Walker has been largely engaged at Manchester in the construction and adaptation of stoves, and that he has had considerable experience in many practical applications of ventilation.

Suggestions for a New Street through the City of London, with a leading Aqueduct Sewer. By Nathaniel Beardmore, M. Inst. C.E. London: Weale, 1850.

Mr. Beardmore proposes a very extensive system of street improvement and drainage. One part of his plan is to do away with Westminster and Charing-cross Bridges, and to construct a grand bridge leading from Charing-cross to the Waterloo-road. Another part is a street from Temple Bar, across Bridewell, south of St. Paul's Churchyard into Eastcheap, and thence by Crutchedfriars and Great Alie-street to the Commercial-road. Coupled with this, he proposes to carry a grand sewer through the metropolis, from Bayswater to Barking Creek.

Royal Agricultural Society's Prize Model Cottages. By Henry Goddard. London: Dean.

Mr. Goddard, an architect of Lincoln, gained the first prize for model cottages offered by the Royal Agricultural Society of England, and we presume that his designs were the best of those presented for competition; but we must say we have seen many designs which are more picturesque, and with better arrangements.

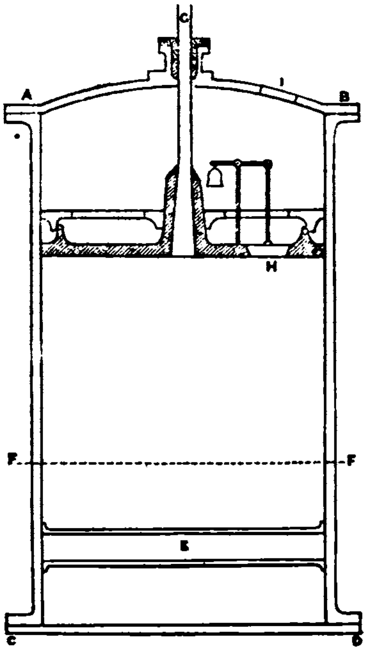
ON COOLING THE ATMOSPHERE OF ROOMS.

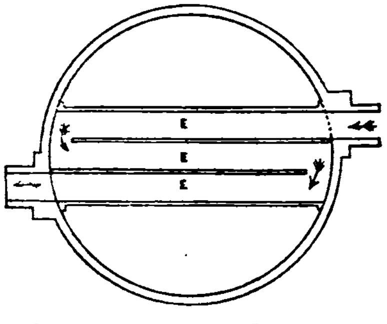
Sir—I was very much pleased with the description given in your last number, of the very ingenious and simple machine for cooling the atmosphere of rooms. Among the many excellencies of the apparatus, not the least, I think, is the similarity between the means employed in it and the operations of nature constantly producing similar effects—I mean the change of temperature by change of density. It is, indeed, an extraordinary thought, that the changes of temperature observed at different heights in our atmosphere may be accounted for by the fact of rarified air having a capacity for heat, increasing with its rarifaction, and that the same air which, made dense by the pressure of the atmosphere, feels so warm at the surface of the ground, may, wafted to some hill top, and thus freed from some part of the pressure, become the cooling breeze; and anon, mounting still higher, may take its place among the regions of eternal snow. It appears to me that the similarity existing between the means employed in the apparatus, and this process in nature, forms the very best guarantee of its effecting the object desired in the most suitable manner, as the parallel between the two operations exists throughout.

It appears to me, however, that some explanation of the cause of the increase of the temperature of air on compression would render the account of the apparatus more intelligible to the general reader, as it might create misunderstanding on the subject merely to say that air increases in temperature on compression, and diminishes on expansion; the fact being, that on compression the same quantity of heat exists in the air as did before compression; but this increase of density diminishing its specific heat (*i. e.* the quantity of heat required to keep it at its former temperature), the amount of heat it possesses above this must make itself sensible, and raise the air to a higher temperature; while, on the other hand, when by being rarified, or being allowed to expand itself in a larger space, its specific heat being increased, the quantity it possesses is unable to maintain its temperature, and it consequently is diminished, though neither change of temperature is in the same ratio as the compression or expansion.

I should scarcely think it possible that the objection anticipated by the inventor—viz., that the cooled air would be found unpleasantly moist, could occur. For, supposing the air to be lowered to the required temperature, it would be able to hold in suspension an amount of moisture in accordance with its temperature; and, of course, any attempt at condensation of moisture must be made by removing some portion of the heat of the vapour. As Dr. Lardner, in his 'Treatise on Heat,' observes (in speaking of the liquefaction of vapour by compression), that without an actual loss of heat having been sustained by the vapour, it would be impossible to imagine the condensation of any portion of the vapour into a liquid, as such condensation must be effected by the subtraction of all the latent heat which maintained the liquid in a vaporous form. But should it be found desirable to lower the temperature of the air more than could be effected (with air subjected to the amount of pressure stated as that best adapted to the purpose) by water of the temperature of 100°, or should it be found impossible to procure water of so low a temperature, I should think (as mechanical power must be used for condensing the air) that the mere evaporation of such water as can be procured—effected as described below, in a space approaching to a perfect vacuum in proportion to the degree of cold required, the vapour arising from the water being constantly removed, in order that its tension might not prevent the further evaporation of the liquid—would amply serve the purpose intended.

This effect might be obtained in the manner shown in the accompanying sketch, where A, B, C, D, is a cylinder, with openings at the sides to connect the pipes containing the air with the air chamber in the cylinder by spigot-and-faucet-joints. Water is to be placed in the cylinder, so as completely to cover the air chamber E, E, E, as shown by the level F, F. In the cylinder, a piston G works. This might be made perfectly air-tight with ordinary hemp packing, the upper plate of the piston being merely provided for the purpose of screwing down the hemp as might be found necessary, and being formed with large openings in it, as shown in the section; while in the lower plate a valve H, is placed, which might be loaded in a proportion relative to the tension of the vapour to be raised from the water. Thus, supposing the required temperature of the water to be 50°. The tension of the vapour of water at 50° is 0·375 of an inch of mercury; and as the amount of the pressure of the atmosphere (15 lb. on the square inch) is equivalent to 30 inches of mercury, it follows that the tension of the vapour of water at 50° is equal to an 80th part of the weight of the atmosphere, which is equal to about three ounces. Now the valve in the piston being loaded in this proportion to its superficies—that is, with a weight of nine ounces—if its superficies is three inches, and so on, it follows, that in the stroke of the piston the valve H would not be affected till the tension of the vapour became of the amount required, and, consequently, would not affect the temperature of the water till it was desirable to do so; and as the valve could be easily loaded with any weight, this would make the apparatus self-acting. The valve I, on the top of the cylinder, might be exactly balanced, so that there would be almost no pressure on the piston from the tension of the vapour above it: some lime also placed in a vessel on the piston would absorb the moisture remaining above it. The rapidity with which water loses its temperature in the exhausted receiver of an air-pump, shows that a few strokes of the piston would absorb enough of the heat of the water to lower it to the required temperature.





In the removal of the vitiated air, I cannot however but think that mechanical means would be far preferable to the mere opening of a sash, as this proceeding must cause a communication with the external air which would be far from desirable. And this circumstance at once brings under consideration the vexed subject of ventilation; that science so well understood in theory, but so lamentably displayed in practice, but which is at the same time a subject of so much importance, that I cannot refrain from quoting the words of a well known writer on this and similar topics. In contending for the superiority of ventilation effected by mechanical means, Dr. Arnott, in his 'Treatise on Warming and Ventilating,' observes, "It is a remarkable fact that the first accomplishment of perfect ventilation for a crowded place was not, as might have been anticipated, in the houses of the great and learned, and therefore in our houses of parliament or in the churches of the wealthy, or in fashionable assembly rooms of any kind—but in the cotton factories. In the first mentioned places it is true that openings were made in the ceilings and side walls, and cowls were placed over the openings or fires, or strong lamps were placed within them to rarify the air and cause it to ascend; but as in all these cases, the important object was trusted to the working of invisible draughts or currents which might not take place, and which very often, from unsuspected countervailing influences, did not take place aright, the object was most imperfectly accomplished. It was in the cotton-factories that fan-wheels were first set in motion, which, *with a certain speed of evolution*, were known to extract *a certain quantity of air*."—In this paragraph the merits of the respective methods are fairly stated, and the plan is also mentioned as simple, and certainly as effective as could be desired.

In conclusion, I think that our best thanks are due to the ingenious and talented author of the apparatus under consideration for his very useful invention; the resemblance of the means employed, with the circumstance which, as he observes, is so often stumbled on by workmen, and is noticed in every work on natural philosophy, proves to us how long a principle may be patent to our senses ere our minds are struck by its applicability to purposes of general usefulness.

I am, &c. Q.

THE ROUTE TO CALIFORNIA BY THE TEHUANTEPEC ISTHMUS.

Mr. Letcher, the American Minister at Mexico, it has been announced, has succeeded in effecting a treaty with the government of that country with respect to the Tehuantepec route across the Isthmus. It is understoodt hat this treaty is similar in its character and conditions to that recently made by our efficient chargé d' affairs, Mr. Squires, between our government and that of Nicaragna. The documents connected with the affair will soon be placed before the senate of the United States. The presumption is, that the stipulations do not vary widely from those incorporated in Santa Anna's decree of the 1st of March, 1842; and in that of Mariano de Salas, dated the 5th of November, 1846. The former decree contained eleven articles, and the third of the series declared that the passage across the Isthmus should be neutral and common to all nations at peace with Mexico. The government generally made this whole decree, upon certain terms, with Don Jose de Garay, who it appears, has surrendered in some way all the concessions orginally made to him to certain citizens of the United States residing at New Orleans. By way of distinction, therefore, this may be termed a New Orleans enterprise, though the results may be of national importance. The treaty was made on the 24th of last month, and it is calculated to call forth much discussion, as well as to excite great interest in every part of the country.

For many years the idea of making an easy route, either by railroad or canal between the Pacific and Atlantic Oceans, has not only arrested the attention of our countrymen, but the serious inquiry of several European governments. A ship railroad, with a capital of 10,000,000*l*. sterling, was proposed at one time in London, with a view of levying tolls upon all the nations of the earth. This was a gigantic scheme. When the mind contemplates the possibility of taking a ship into a dry dock on the Atlantic shore, of cradling it upon a car with 48 wheels, running upon eight rails, of seeing it transported across the country, and deposited in a dock upon the Pacific, the ingenuity of man becomes an object of admiration. We are startled with its boldness, though we can scarcely doubt the rationality of its recources. Vast capital can accomplish vast results. However, the English plan will not be carried into effect in the present century. The French and the Germans have made several surveys of different routes, as well as the English and Americans. That by Tehuantepec may or may not be practicable. Senor Gaetano Moro's survey gives a highly favourable picture of the country for the proposed road. From his surveys, it seems that the entire distance from sea to sea is 135 miles in a right line. It presents a wide plain from the mouth of the Coatzacoalcos to the foot of the Mesa de Tarifa, which is a table-land rising to 650 feet above the level of the sea, and at five miles distance decends again to the plain which reaches the Pacific. Near Tehuantepec, Moro found two extensive lakes, the outer separated by a narrow sandbank from the ocean, and the inner and larger communicating with it by a channel between high banks. Eight rivers flow into them, and, with some improving, ships may find harbours in these waters. From the inner lake the land rises very gradually to the Venta de Chicapa, thence with a steeper acclivity upon Tarifa,—and there is a slight declivity to a river, which is navigable for ships for the distance of 34 miles from its mouth on the Gulf of Mexico. Such are the rude outlines of Moro's survey.

The resources of the country are immense for timber of the best quality for building a road. The facilities for cattle-feeding are complete. The soil is prolific, and salt mines are abundant. The climate is agreeable and mild, and usually salubrious. The advantages, therefore, for constructing a road cannot be overlooked. In a commercial and political point of view, however, such a road would be very desirable; and, could it be made, would add largely to the prosperity of our country. From the mouth of the Mississippi to San Francisco, by Tehuantepec, is 1825 miles nearer than by Panama. From New York 1400 miles of sea navigation would be saved, were this route opened.

THE VICTORIA REGIA HOUSE, CHATSWORTH.

We are indebted to the *Gardeners' Chronicle* for the plans and elevations of the hot-house erected at Chatsworth, for the cultivation of the Victoria Lily, together with descriptions and explanations by Mr. Paxton himself. This structure is of great interest; showing, as it does, in how simple a manner large spaces may be covered with glass, and yet be suited for all the purposes of cultivation. It will also indicate the earliest conception of the palace of glass which is to receive the products of industry of all nations in 1851.

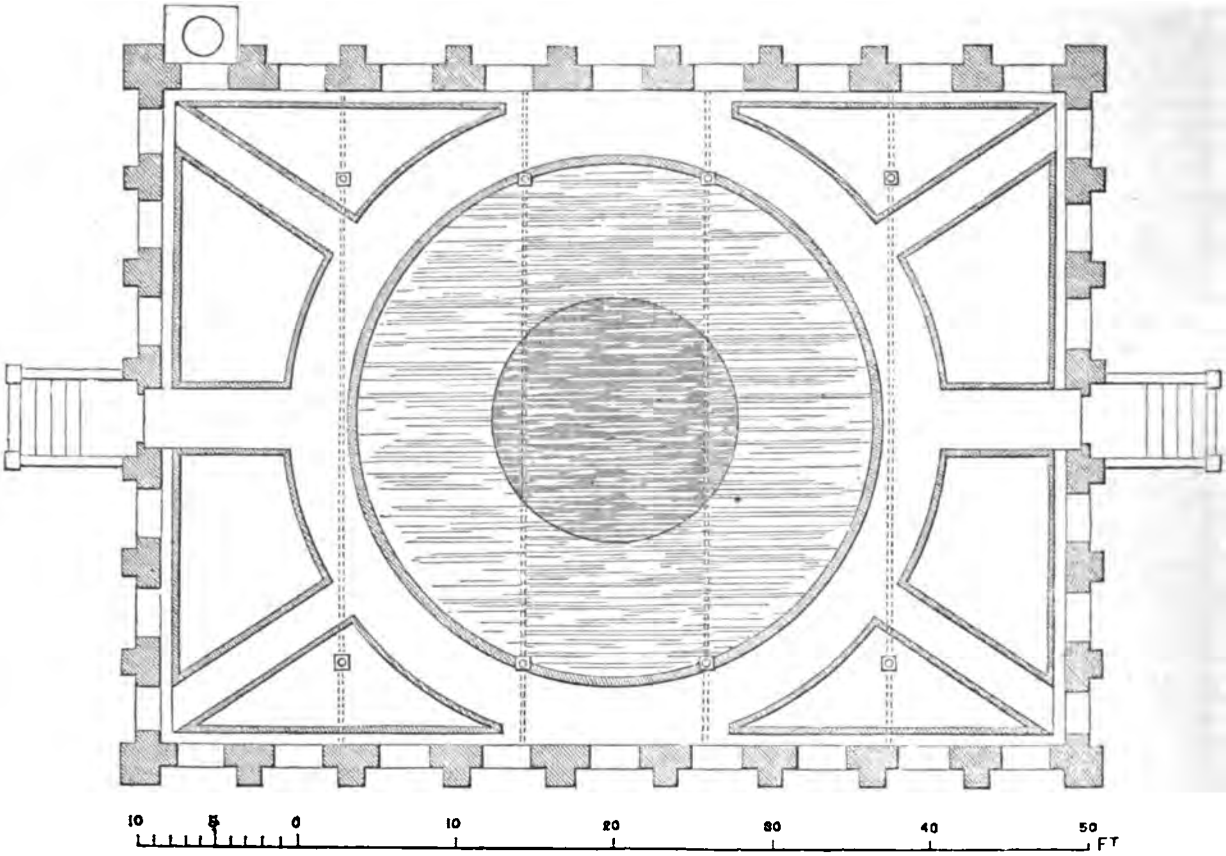


Fig. 1.—Ground Plan.

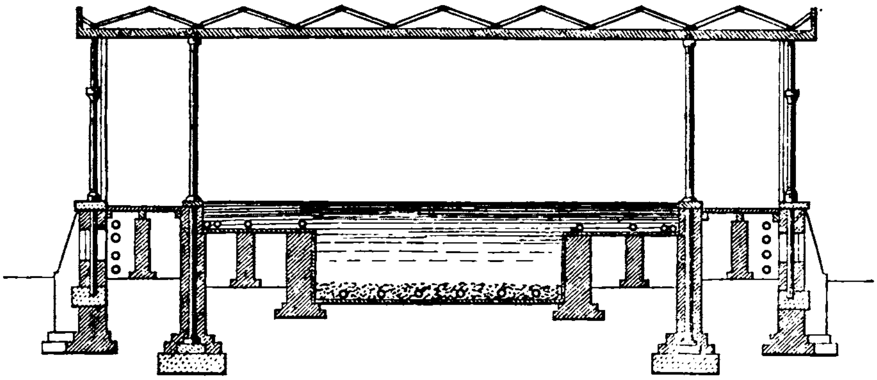


Fig. 2.—Transverse Section.

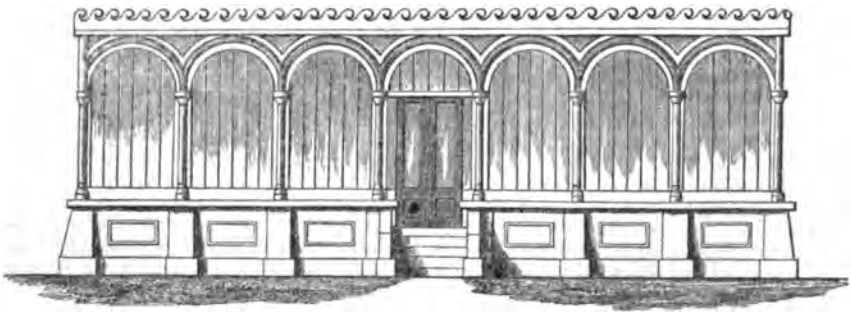


Fig. 3.—End Elevation.

Fig. 1 represents the ground plan, which is 61 ft. 6 in. long, and 46 ft. 9 in. wide over walls. The circular tank is 33 feet diameter, and the centre part, which contains the soil for the plant, is 16 feet diameter. The eight tanks in the four angles are filled with aquatic plants of various kinds. The house is heated by a series of 4-inch cast-iron pipes all round the inside of the external walls, proceeding from a Burbage and Healey's boiler, and Sylvester furnace. The tanks are heated by 4-inch pipes underneath each, as shown in the section; and by smaller sized lead pipes resting on the paved ledge of circular tank, also shown in the section. There are 30 openings between the piers, all round the house, for ventilators. Different compartments of the roof are also made to open by simple machinery, for the purpose of ventilation. The pathways are raised 3 ft. 6 in. above the general level outside, and the roof is supported by light wrought-iron beams, resting on the eight internal columns, as shown on the ground plan.

Fig. 2 is a transverse section of the building, which shows a section of the circular tank, with the pipes under the centre part, and the small pipes on the paved ledge, forming the shallow part of the tank. Also the side pipes, and the manner of fixing the cast-iron columns; together with the construction of the roof and its gutters, facia board, &c. The wrought-iron beam shown in this section has a bearing in the middle, over the great tank, of 31 ft. 3 in. The height of the masonry, from the ground to the top of the coping, is 4 ft, 9 in.; the column and arch 10 ft. 6 in.; the plating and facia board 2 ft. 1 in., making the whole height from the ground line 27 ft. 4 in. By this section it will be seen that the upright sashes are placed behind the cast-iron columns.

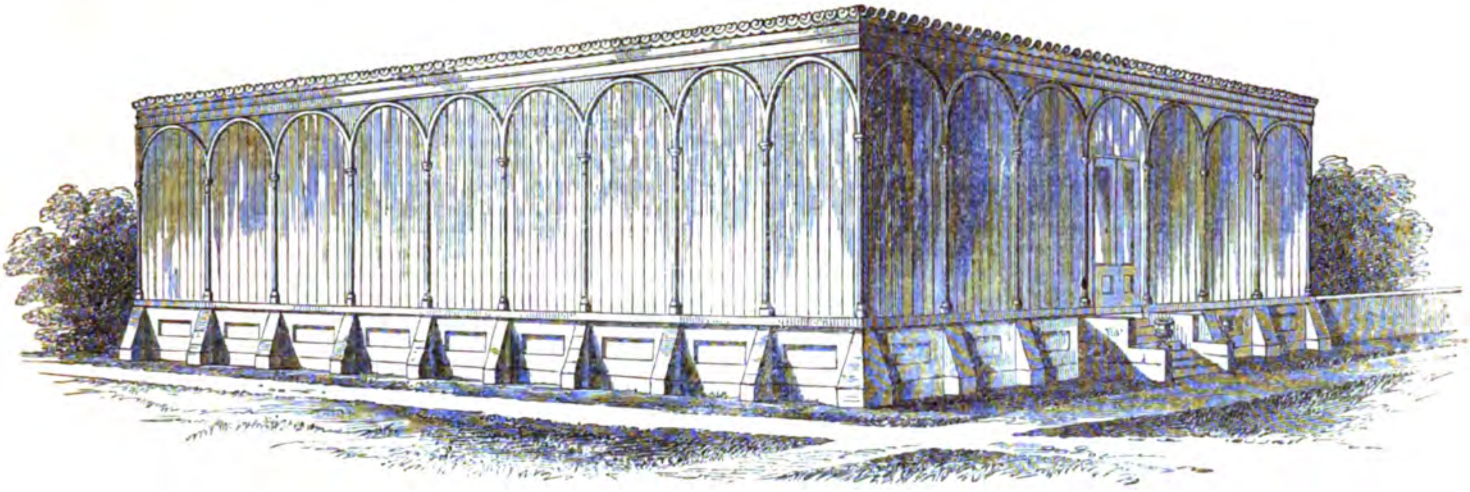


Fig. 4. - Perspective View of the Exterior.

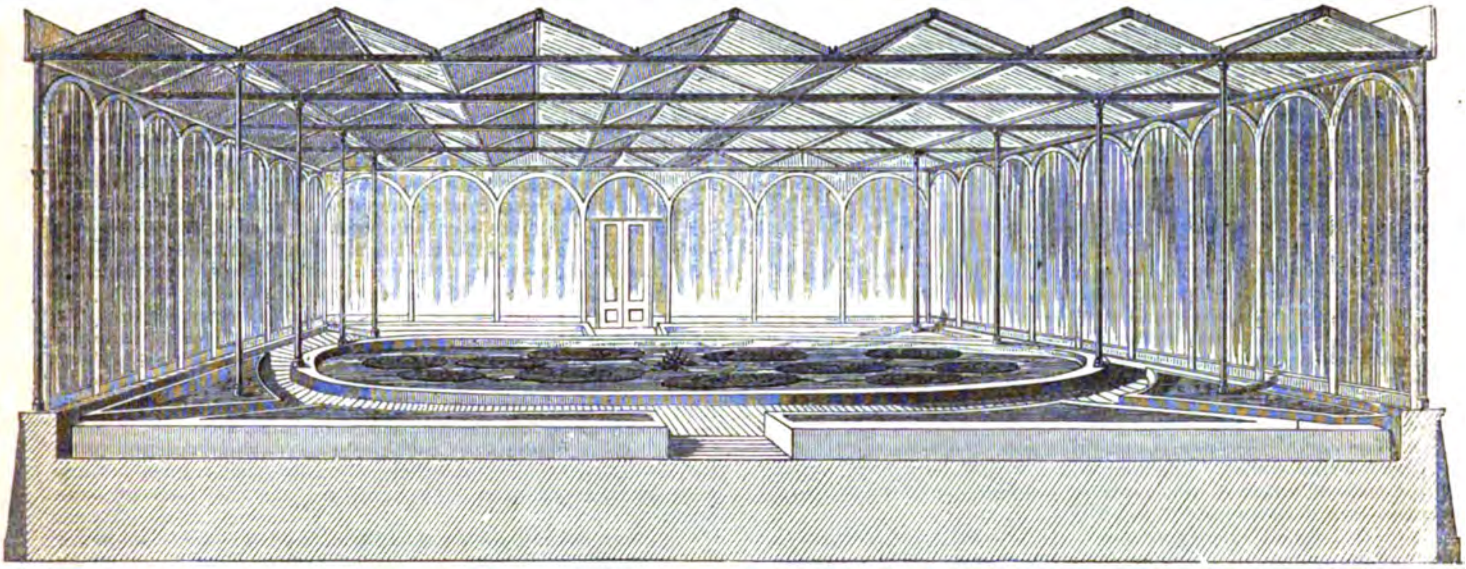


Fig. 5.—Interior View.

Fig. 3 represents the end elevation, and shows the steps ascending to the entrance, the ventilators, cast-iron arches, and facia board over the plating. The upright glass is 10 inches wide between the bars, and each spandril between the arches is filled in with one piece of plate glass. The columns are 6 ft. 6 in. from centre to centre, and the side elevation of the building presents a series of nine arches, as shown in the exterior view.

Fig. 4 is an angular view of the building; both ends are alike, and both sides are of the same form. On the east side, which fronts the park, the masonry is partly hid by artificial rock work, and the ends and steps to the entrances are adorned with ornamental plants.

Fig. 5 is a parallel perspective representation of the interior, showing the internal construction, the mode of supporting the longitudinal ridge and valley, wooden rafters of the roof, &c.

CONSTRUCTION: *Mason, and Castings.* — The foundations of external walls and tank walls are built of solid rubble work, well bedded in mortar. The curb of circular tank above the pathways, and curbs of the angular tanks, are of brick, cemented. The tanks are laid with pavement and covered with lead. The external walls are built of picked scappled coursed wall-stone, with piers battering 9 inches, and a plinth formed of two courses of wallstone projecting two inches. The steps to entrances and curb walls bounding them are of rubbed grit stone, and the walls are covered with neatly boasted and weathered coping. The cast-iron columns are 4 inches at the lower diameter of the shaft, and 3½ inches in the upper diameter. The cast-iron of the arches is 3½ inches wide, by 2½ inches thick, chamfered. The wrought-iron beams are 5 inches by 1 inch, with tension rods 1 inch in diameter.

Carpenter, &c.—The platings are 5 inches by 12 inches, the valley rafters of roof, 6 inches by 4 inches; and the ridge rafters, 5 inches by 3½ inches; with strengthening pieces over each Iron beam, and sash bars 1½ inches deep. The ventilators are bead and flush, hung on the pivot and socket principle, in rebated wooden frames. The stiles and arches of upright sashes are 2 inches thick, together with the doors, which are framed and panelled, and furnished with brass locks and brass butts. The pathways are laid with 1½ inch larch boards, ½ of an inch apart, radiating round the centre tank, and resting upon oak sleepers 4 inches by 3 Inches. The roof ventilators are framed and glazed, and hinged to the rafters. The facia boards are wrought and cut out, as shown on the upper part, with mouldings planted on the plating, to form a cornice. The scroll is completed by painting in different shades. The curbs of all the tanks are finished with a neat rounded edge wooden capping, and the circular tank is provided with a neat railing and hand rail all round. The whole of the house is glazed with sheet glass 4 feet long by 10 inches wide, without overlaps in upright sashes, all being close jointed. Every part of the masonry or brick work seen from the inside, is covered with cement, and the whole of the structure, both externally and internally, is thoroughly painted in suitable and ornamental colours. The accompanying design, described in the foregoing paragraphs, is the type of my design for the building for the Great Industrial Exhibition of 1851. When the large conservatory at Chatsworth was built, a great point was gained by being able to have the glass manufactured in sheets of 4 feet in length; but since that period the improvements in different branches of manufactures have enabled me to make the present Lily-house (though comparatively small) of a much more light and elegant appearance.

It occurred to me that it only required a number of such structures as the Lily-house repeated in length, width, and height, to form, with some modifications, a suitable building for the exhibition of 1851. Hence arose the design for that structure, and the subsequent honour conferred upon me by its unqualified adoption by her Majesty's commissioners. *J. Paxton.*
Chatsworth, August 13.

BRITANNIA AND CONWAY TUBULAR BRIDGES.

The Britannia and Conway Tubular Bridges; with General Inquiries on Beams, and on the Properties of Materials used in Construction. By Edwin Clark, Resident Engineer. Published with the sanction and under the supervision of Robert Stephenson. London: Day and Son. 1850.

In the notice we first gave of this excellent work, we confined ourselves to remarks on the book itself, and the influence which tubular bridges will exercise on engineering, and from the length to which those remarks extended, we were precluded from giving any extract from the book, and which we promised to do, knowing the interest our readers feel in this one of the most important works of the age, and one which will not be least sought after by visitors to this island in the coming year.

In consequence of the requirements of the Admiralty, it became necessary to design a new bridge over the Menai. The first plan for this is thus described by Mr. Robert Stephenson himself:—

"Previous to the erection of the suspension-bridge by Telford, in 1826, various modes and points of crossing had been proposed by Rennie and Telford. Their reports, plans, and opinions, were carefully studied, which led to the adoption of the site known by the name of the Britannia Rock, about a mile to the south of Telford's suspension-bridge. This spot is peculiarly eligible for the purpose, the rock being nearly in the centre of the channel, rising just to high-water mark, and of sufficient area to admit of the easy erection of a pier upon it. The channel is here also entirely free from sunken rocks, and the current unbroken during the ebb and flow of the tide. These peculiarly favourable circumstances were considered highly advantageous, not only for facilitating the erection of a bridge, but for rendering such a structure unobjectionable to the navigation of the Straits. It was proposed to construct the bridge of two cast-iron arches, each 350 feet span, with a versed sine of 50 feet, the roadway being 105 feet above the level of high-water at spring-tides.

"The span here proposed was the same as that which had from the first been designed for crossing the Conway River.

"Such was the state of the engineering problem in reference to the Conway and Britannia Bridges when the company obtained the first Act of Parliament in July, 1844. It was proposed to construct a bridge consisting of one arch of the unusual span of 350 feet over the Conway River, at 20 feet above high-water mark, and another over the Menai Straits at the Britannia Rock, consisting of two arches, each of similar span, but at the elevation of 105 feet above high-water spring-tides.

"The rise of tide in both cases is nearly the same, the channels are also very similar, being from 50 to 60 feet deep, with a rocky bottom, and a rush of tide reaching five miles an hour at Conway, and seven miles an hour in the Straits.

"These conditions, together with the necessity of keeping the channels open at all times for the purposes of navigation, rendered it perfectly clear that none of the methods heretofore adopted in the erection of cast-iron arches could be brought to bear in either of these localities. The inordinate cost of centering, even if other arrangements had admitted of its application, was at once fatal to its adoption; and it soon became evident that some means external to the arch should be employed to suspend the voussoirs, or ribs, until the arch was keyed in.

"A contrivance of this kind had at one time been considered by Telford for the suspension of centering, upon which he proposed to frame and connect the voussoirs, or ribs, of a cast-iron arch; and a slight drawing of such a project is given in the account of the Menai Bridge. Without going into the merits of this proposal in the form suggested, or into its applicability to the present case, it is sufficient to say that it was discarded, and a modification, as brought forward some years ago by Sir Isambard Brunel, for constructing brick arches without centering, taken up as more suitable. Sir Isambard's idea, which was experimentally carried out to a great extent, appeared unexceptionable, and led to the following design for the erection of the cast-iron arches at the Britannia Rock. Instead of the two arches being erected upon two abutments and one pier, it was proposed to treat the abutments as piers also.

"The erection of the arch was to be proceeded with by placing equal and corresponding voussoirs on opposite sides of the pier at the same time, tying them together by horizontal tie-bolts.

"This system, it is confidently believed, may be successfully carried out to a far greater extent than would have been required in the case of the Britannia Bridge.

"It will appear evident, on a little reflection, that as every succeeding step of voussoirs is secured by the tie-bolts, the tension of the last bolt, as well as all the previous ones, will be relieved by an amount equal to the whole of the horizontal thrust due from the voussoirs last placed.

"If the voussoirs could be constructed or weighted, so that an arch of equilibrium could be formed, all the horizontal tie-bolts might be removed, except the last one, for in such an arch the horizontal thrust is every where equal. It is not meant that such a method of proceeding as that of removing all the bolts could be carried out practically—it is merely alluded to here to show how largely the bolts would have been relieved from strain as the arch progressed into a form which might appear to endanger the stability of the structure.

"Had this plan been carried out, it was not intended to have keyed the arches at the crown, but to have left ample space between the culminating voussoirs to admit of expansion and contraction taking place freely. The bridge would, therefore, have been simply a double-jibbed crane, perfectly balanced on each pier. A connection at the apex of each arch would be necessary, but so contrived as not to interfere in the least with the expansion and contraction, and yet to counteract any tendency to tilt, consequent upon the variable pressure of the passing loads.

"This mode of construction, although decided upon for the Britannia Bridge, was found unsuited for that of Conway. There only one span was required, and the springing of the arch would have been below the high-water line, and from a natural mass of rock on both sides, which, at the east extremity, rose nearly to the permanent level of the railway.

"It was, consequently, impossible conveniently to treat the abutments in the light of piers, as has been just described. Moreover, the great additional expense of this method, where one arch only is required, formed a serious objection to it, as it necessarily involved the use of double the weight of material requisite for one simple arch, the weight of each overhanging wing being equal to half the weight of the arch itself.

"The objection on the score of expense did not apply to the Britannia, for there the overhanging wings were a useful portion of the bridge, and formed a substitute for the extension of masonry, which would have been nearly as costly. Both the expense, therefore, and the peculiarity of the site of the Conway Bridge, pointed out the necessity of some other method being devised for the erection of the arch. Various modes for erecting and supporting a fixed centering were considered, but none appeared satisfactory or safe; whilst the formidable difficulty of stopping the navigation, and seriously interfering with many vested interests for probably two years, remained in all its force.

"This state of things led to the idea of building the arch complete on centering supported entirely upon, and framed into, a series of pontoons kept afloat during the whole time of construction.

"The rise and fall of the tide was such as to admit of its being brought immediately above the springings and lowered into its place by the falling tide, or by admitting water into the pontoons at the top of the tide, before the velocity of the ebb stream had increased so as to interfere with the accurate adjustment of the descending mass. This method of fixing arches I have since learned was proposed many years ago by Mr. Dixon, of Darlington. He made designs for a cast-iron bridge across the River Tees at Stockton, and, instead of erecting centres on the permanent site of the arch, he proposed to use pontoons, precisely in the manner which has been described. These plans were not carried out, in consequence of the Stockton and Darlington Railway Company having determined to try a suspension bridge for railway purposes instead of the cast-iron arch. For a brief description of the particulars of the novel proposal of Mr. Dixon I have been favoured with a communication from Mr. R. B. Dockray, who resided at Darlington at the time when Mr. Dixon made the design. I have also learned from Sir John Rennie that this was the method adopted for placing the centering of the Waterloo and London Bridges; the centres being constructed on pontoons and floated and lowered into their proper position."

We very much regret that this ingenious plan of Mr. Stephenson was not adopted, in consequence of the hostility he had to encounter on the part of the government; but we hope the opportunity will present itself for its realisation under his direction.

In reference to one of the original forms of the tube, the circular, Mr. Edwin Clark makes some interesting remarks.

"It is to be regretted that circular tubes, with thicker plates, were not experimented upon; as subsequent experience has shown that no distortion would then have occurred, and valuable results would probably have been obtained. Permanence of form might, moreover, be entirely ensured by diaphragms or stops, at intervals, throughout the tube, or by stiffening-plates united by angle-iron, as in the bridges. Such diaphragms have, indeed, been successfully adopted by Professor Airy in using wrought-iron tubes for the support of astronomical instruments, to which purpose they are peculiarly applicable, on account not only of their stiffness, but of their greater freedom from vibration or tremor than cast-iron supports. Diaphragms are used in the construction of the wrought-iron polar axes of the large equatorial telescope in the Observatory of Liverpool, which are formed of two semi-elliptical boiler-plate tubes, of exquisite workmanship.

"Circular wrought-iron tubes, of considerable thickness, and of magnificent dimensions, retained in shape by stops, are also being used by Mr. Brunel in the construction of a bridge over the Wye, at Chepstow in South Wales. These tubes are, however, not strained transversely, except in supporting their own weight during the process of erection, and for this purpose it is intended to render them temporarily more rigid by cambering them to a slight extent by tie-rods along the bottom. They are 305 feet long, 9 feet diameter, and $\frac{5}{8}$ inch thick; and are employed as struts, or pillars, to resist the horizontal strain of the suspension links which support the wrought-iron girders of which the bridge is composed. By these means, without the usual tie-chains of a suspension-bridge, the lofty towers are relieved from all lateral strain.

"The total span of this bridge is 300 feet, which is the length of the circular tube employed as a strut; a chain, consisting of three straight links, suspended from this strut, divides the span into three equal portions of 100 feet each. The beam carrying the roadway is thus a continuous beam, 300 feet long, supported at each end and at two points in its length. The circular tubes are supported on cast-iron standards.

"Circular tubes, 100 feet high, were also at one time proposed as supports for the platforms in constructing the abutment-tubes of the Britannia Bridge.

"The round tube, as proposed for the bridge itself, if suspended in chains, and merely applied as a means of ensuring a rigid platform, would, if constructed with thick plates, properly united, have formed a most efficient structure, offering but little resistance to the wind, and having equal rigidity in every direction; while an elliptical tube of the depth necessary for the Britannia Bridge, and well retained in shape, possesses several important advantages as an independent beam. The curved plates of the top are well adapted for resisting compression, and for throwing off the wet, while the heavy riveting necessary for uniting the sides with the top and bottom in a rectangular tube is entirely obviated; although there are other more important practical advantages in favour of the rectangular form.

"We have many instances, in the vegetable kingdom, of the extreme rigidity and strength of circular tubes: the stems of the grass tribe generally are remarkable for their lightness and strength; the common wheat-straw and the river reed are familiar examples in our own climate; but in the tropics the gigantic stems of the bamboo and other grasses tower sixty feet above the jungle, and are extensively employed as beams for covering buildings, and even, in some cases, as the transverse bearers of light suspension bridges. The angler's bamboo rod is the most perfect of tubular beams. Tapered off in proportion to the strain, its salicious coat (as in all the grasses) defies compression, while it is internally lined with woody fibre to resist extension in every direction; its strength, lightness, and stiffness, are thus equally marvellous; and we cannot fail to be struck with the provision of diaphragms throughout the whole tribe, to preserve the circular form, which addition would certainly have much modified the results obtained from thin circular and elliptical tubes of wrought-iron.

This illustration from the vegetable kingdom, is only one among many examples of the writer's happy power of treatment, and will enforce upon our readers the importance of the study of animal mechanics, which so far as we are aware is not taught in any engineering college.

In reference to the ultimate length to which it is possible to carry the tubular bridge, Mr. Edwin Clark has several remarks, which we think will prove of interest to our readers, and in the discussion of which Mr. Clark again alludes to the works of nature.

"Again, if we make a tube similar to another, increasing every dimension except thickness, the absolute strength will be directly as the increase, that is to say, another tube twice the length, depth, and breadth of the Conway Bridge, but of the same thickness, would be just twice as strong; it would, however, be four times as heavy, and hence have four times the strain from its own weight, and would, therefore, soon come to a limit at which it would break itself.

"This is evident by considering that with tubes of similar section, in which the thickness is not altered, the sectional area will be simply as the increase, and not as the square of the increase; the strength will therefore be simply as the lineal dimensions, instead of as their square.

"But if we increase a tube in depth, and length, and width, and preserve its sectional area constant, that is, if the plates are thinner in the same proportion as the tube is enlarged, then the absolute strength of the enlarged tube *ad infinitum* will be the same as that of the first. So that by keeping the same sectional area as at Conway, and enlarging in the same proportions the length, breadth, and depth, we may make a tube of any length, equally strong, theoretically, with the Conway Tube. For the strength is directly as the sectional area into the depth, and inversely as the length, and the sectional area being constant, as well as the ratio $\frac{\text{depth}}{\text{length}}$ the strength will also be constant; but the weight of the tube, and hence the strain from its own weight, would increase as the length; and, consequently, if we suppose the strain to be five tons per square inch at present in the Conway Tube, another tube of the same sectional area, and of three-and-a-half times the same length, breadth, and depth, would fail by its own weight. Such a tube would be 1400 feet long, and no increase of thickness would make such a tube bear more than its weight.

"We have already alluded to the strength of the bamboo as an instructive natural example of the strength of a circular tube. The bones of animals are oval, the depth being always in the direction of the transverse strain. But the more special province of the bones appears to be their action as pillars, or struts, in forming immoveable fulcra for the reaction of the muscles; and since any yielding would involve a great increase of motion in the muscle itself, we find bone among the most incompressible of known substances.

"The square form of stem characterises a very extensive natural family of plants—the labiate tribe, of which the beautiful dead nettle of the hedgerows is an example; though it is difficult to assign any mechanical reason for this peculiarity, which appears rather to be typical of the general developement of these plants. But in the feather-bearing part of the ordinary quill we have a most remarkable example of the strength of the rectangular form. Here, again, every dimension is tapered down in proportion to the strain, with an accuracy defying all analysis; the extended and compressed portions are composed of a horny substance of prodigious strength, though extremely light and elastic. The beam is not hollow, but to preserve its form it is filled with a pithy substance which replaces the clumsy gusset pieces and angle-irons of the tube without interfering with its pliability; the square shaft is peculiarly available for the attachment of the deep vanes which form the feather; and as the angular form would lacerate its active bearer, an exquisite transition to the circular quill at the base is another striking emblem of perfection. The imitation of such mechanics, so wonderfully adapted to such a medium, appears hopeless; but we are indebted to the flying philosopher, if his attempt only calls attention to such design, and induces us instructively to contemplate the beauty of a feather."

REMARKS ON SPIRIT-LEVEL ADJUSTMENTS.

There are some misapprehensions prevalent affecting the manipulation required for properly adjusting the spirit-level, and the reasons which occasion it. Such errors, if copied from one text book into another, are likely to mislead some of the profession, who may not have leisure to examine for themselves.

The object of the adjustments should be to enable us to obtain at any place a straight line of sight, revolving in a plane; this plane to be a tangent to the earth's surface at that place.

The term *optical axis* is sufficiently explanatory; the term *line of collimation* is not so. Mr. Simms, in his 'Treatise on Levelling,' writes, *optical axis, or line of collimation*. This description, if intended for the old-fashioned Y-level, in which both should coincide, would be correct; but is inapplicable to that with fixed telescope at present in general use. In the latter the adjusted line of sight may or may not form an angle with the optical axis of the lenses. Provided the line of sight be parallel to the bubble, and at right angles to the vertical axis on which the telescope turns, it is of little consequence whether or not the line of sight be precisely *in directum* with the centre line of the lenses. The amount of distinctness occasionally lost by the want of this coincidence is altogether inappreciable.

If this then were the only difficulty attending the adjustment of the diaphragm, we could not do better than, pointing the instrument at a placard lettered with various type at some distance, move the diaphragm up or down, until the horizontal wire appearing in centre of the field might be seen to intersect those letters most distinctly defined. The adjustment required is, however, of a different nature. Mechanical error would almost unavoidably, during focal adjustment, cause the focus of the eye-piece to deviate from the path of a line of sight so determined upon, since it is very doubtful whether it would be possible to construct tubes to slide one within the other with the nicety which this would require. This source of error, with a remedy, was first pointed out by Mr. Gravatt; but his method seems (as I shall show) to be at least liable to misinterpretation, if not capable of improvement, and perhaps correction. The object of his adjustment he defines to be, "to examine and correct the line of collimation." Had he, instead of this, described it as a process to correct error arising from focal adjustment, mistake on this head would not have been so likely to occur. Having described the process, to which I shall have occasion again to revert, he adds: "The instrument will now be in complete practical adjustment for level, curvature, and horizontal refraction, for any distance not exceeding 10 chains, the maximum error not being more than $\frac{1}{1000}$th part of a foot." This might perhaps have been with advantage omitted, as the three sources of error alluded to in this paragraph, remain unaltered by the adjustment described—the same exactly whether the adjustment had taken place or not.

1°. The steps of this adjustment involve the following principle: three stakes, A B C, are driven in to the ground, equidistant, and tops in a curve of true level. Set the instrument up at A, using the bubble merely to see that you do not disturb the instrument; take the readings of the staff held on each stake consecutively, and if the difference of the readings at A and C be four times the difference of the readings at A and B, the line of sight is unaltered by focal adjustment, on the principle that the radiating differences between true and apparent level vary as the squares of their respective distances from the point of contact of the tangent and curve; if not, alter the diaphragm till this proportion take place.

2°. Next, lower or elevate the telescope by means of the parallel plate-screws until the line of sight so adjusted and apparent level coincide, and set the bubble parallel to it.

3°. Get the line of sight and bubble at right angles to the vertical axis of the telescope in the usual manner.

With regard to No. 1, which from its importance deserves most consideration, since the bubble is used merely to see that you do not disturb the instrument, the line of sight may be a *secant* to the curve marked on the ground, and not a tangent, which circumstance might negative this adjustment without due precaution; but if the bubble and optical axis are nearly parallel when the instrument is obtained from the optician, and the bubble be brought to *the centre of its run* previous to taking the readings, I do not believe sensible error likely to accrue from this source.

The manner in which focal error is got rid of may be explained as follows: Suppose the instrument placed, the set in apparent level, and a staff held vertically at a considerable distance, appearing in the centre of the field of the telescope. Suppose, further, this staff to advance or recede, without altering its relative position to the optical axis; a single point of the image of the staff will travel backwards or forwards horizontally within the tube; the paths of the remaining points will all be less or more inclined to the optical axis, forming every variety of angle with it, according as they are nearer to or further from this normal point. Suppose, further (which is more than probable), the tube carrying the eye-piece not to slide *in directum* with the optical axis, but in another line, we must then raise or depress the diaphragm out of the optical axis, till the cross hair meet a ray from the staff whose path shall coincide with that of the focus of the eye-piece during focal adjustment. This is evidently *possible*, and no method better to effect this than Mr. Gravatt's, with the precaution already mentioned.

This adjustment, once made, need never be repeated. The remaining two adjustments may then be performed in the usual easy manner.

There is, however, considerable grounds for supposing misapprehension to exist on this head among many who practise and some who write. I shall conclude these remarks with a specimen of the latter kind, taken at random from a text-book lately published, where, speaking of Mr. Gravatt's method, the writer says: "We are indebted to Mr. Gravatt, of whose level we shall hereafter speak, for a method of collimating which satisfies the above requirements, and removes any error arising from imperfection in the slide of the telescope, while at the same the line of collimation is set with the end at the object glass slightly depressed, instead of exactly horizontal, so as to remove, or nearly so, the errors arising from the curvature of the earth, and the horizontal refraction."

Cirencester. J. D. Pemberton.

BRITISH ASSOCIATION.

Selections from Papers read at the Meeting held at Edinburgh, August, 1850.

(*Continued from page* 304.)

Description of a New Arrangement of Reflecting Telescope, by which much comfort and convenience is secured to the Observer. By James Nasmyth.

In introducing this subject to the attention of the members of the Mechanical Section, Mr. Nasmyth, with a view to render the description of his improved arrangement of telescope more clear to such members as might not be practically conversant with the subject in question, premised his description by a sketch of the various forms of reflecting telescope which had hitherto most generally been in use. These are seen in fig. 1, 2, 3; fig. 1 being the Newtonian, which is the arrangement *most generally* in use for the larger and most powerful instruments. It will be seen, that in the case of fig. 1, the object is viewed by the observer placing his eye at the side of the tube, and at the end most distant from the speculum S, the image of the object being seen in that direction by means of the employment of the small diagonal plane mirror at D. In telescopes of this construction, the eye of the observer is placed near the upper end of the telescope; thus, fig. 6. It is therefore requisite that he must change his situation almost constantly, so as to follow with the telescope the movement of the star, or other astronomical object he is desirous to look at. In telescopes of a moderate size, this may not be found to be a very serious source of inconvenience; but when we come to employ instruments of this class, of a larger and more powerful description, the difficulty of following the eye-piece of the instrument, when its posi-

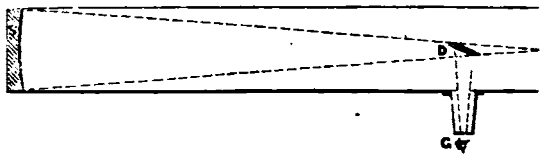


Fig. 1.—Newtonian.

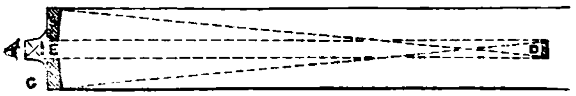


Fig. 2.—Gregorian.

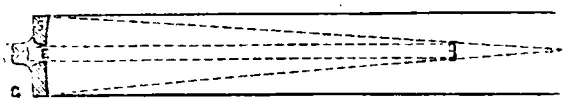


Fig. 3.—Cassegrain.

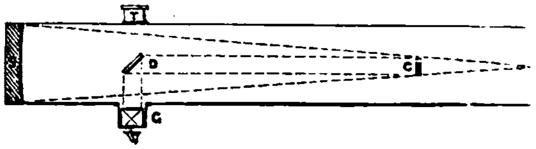


Fig. 4.—Nasmyth.

tion has to be changed, so as either to follow the object or pass to another, is felt to be very great; and even although many excellent arrangements of mounting have been proposed to overcome this difficulty, yet so much personal inconvenience, discomfort, and trouble yet exists in all of them that the attention of the observer is in no small degree occupied and divided between regard to his own comfort and safety, and the actual object in view. Although such discomforts might in some respect be reduced in the case of the employment of the arrangement, fig. 2, namely, that of the Gregorian; or fig. 3, that of the Cassegrain construction, in both of which it will be seen that the observer views the object from the lower end of the tube, thus, fig. 7; yet although the observer may not in this case have *so often* to mount up to the top of high ladders, and be so far in bodily fear as is but too much the case, as in fig. 6, yet the continual change in his position and the awkwardness of having frequently to crouch down in uncomfortable postures, detracts so much from that *ease of person* which is so requisite in the conducting refined observations, or for enjoying with due tranquility views of the glorious objects scattered throughout space, that after considerable experience with telescopes of a large class, Mr. Nasmyth bethought himself of such an arrangement as would remove most of these objections. The optical department of this arrangement is seen in section in fig. 4, where it will be observed that, by the union of the Newtonian and Cassegrain construction, in so far as respects the turning back of the cone of rays by the small convex mirror, C, and receiving them at D, by a small diagonal plane mirror, D, the rays which ultimately form the image of the object are sent out sideways through the *trunnion*, G, in which the eye-piece is placed, and through which, in fact, the observer views the object.

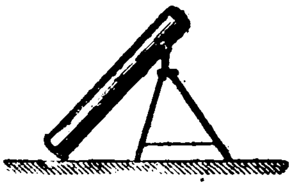


Fig. 6.

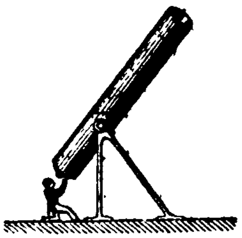


Fig. 7.

By having a corresponding trunnion at the opposite side, T, and employing these trunnions as the supports of the telescope, and using them as the axis on which it is moved in altitude, it will be evident that, as the eye-piece, G, is thus *in the centre of motion*, whatever be the sweep of elevation in moving the telescope vertically from object to object, no change in the position of the eye of the observer will be required; his eye, while opposite to the trunnion, *is common* to all positions of the instrument in altitude; his eye is virtually in the centre of motion.

But as the telescope has to be moved round so as to follow the motion of an object in azimuth, it is desirable that the observer should not have to change his position even in this respect. Therefore, in order that he may sit at his ease opposite to the eye-piece while the telescope is moved either in altitude or in azimuth, all that has to be done to attain this object is to *place the entire instrument on a turn-table*, and have a comfortable seat for the observer also on the turn-table, and then, whatever be the elevation or direction in which the telescope is pointed, the observer need never stir from his comfortable seat; and as we all now know with what ease ponderous machines, such as railway wagons or locomotive engines, can be swung round on properly constructed turn-tables, and also the ease with which a well-balanced mass can be swung when it centres, some idea may be formed of the perfect ease and facility with which such an instrument as this of Mr. Nasmyth's can be governed and directed by the observer, who has, by means of suitable handles brought close to his chair, the most perfect command of every requisite movement. The instrument in question, which is represented in fig. 5, weighs upwards of two tons, can be moved in every direction by the point of the finger, swung round in an instant, or elevated to any object on a slow motion given to it so as to enable the observer to keep the object in the centre of the field for hours. Such is the perfect steadiness of the motion, that not the slightest tremor is perceptible, even when observing with a magnifying power of 450 times. Some objection may be urged against the optical arrangement by which Mr. Nasmyth has brought his telescope to yield this central vision, in so far that it is requisite to employ a *third* reflecting surface, namely, the small plane diagonal mirror (D, fig. 4,) by means of which we are enabled to view the object through the hollow trunnion G, fig. 4, or B, fig. 5; no doubt some portion of light is sacrificed by the employment of this third reflector; but when we obtain in exchange so vast an amount of convenience and comfort as result from the adoption of this arrangement of Mr. Nasmyth, most observers will be happy to accept the exchange, and with the advantage of the ease, comfort, and tranquility resulting from the absence of all personal sources of interruption, Mr. Nasmyth presumes that by thus inducing more frequent and careful observations, science will be advanced.

Mr. Nasmyth stated, that the main object he had in view in constructing this large telescope was not so much to pursue observations of objects of the fainter class, as nebulæ, &c., but rather for following up a series of observations in reference to the structure of the lunar surface, on which subject he has been occupied for several years; and such has been the increased comfort and facility which this truly manageable and powerful instrument has given him, that, judging from the specimens of the "drawings from nature," of the remarkable features of the lunar surface, which he exhibited to the Section, the optical powers of his instrument are equal to its convenience and comfort to the observer.

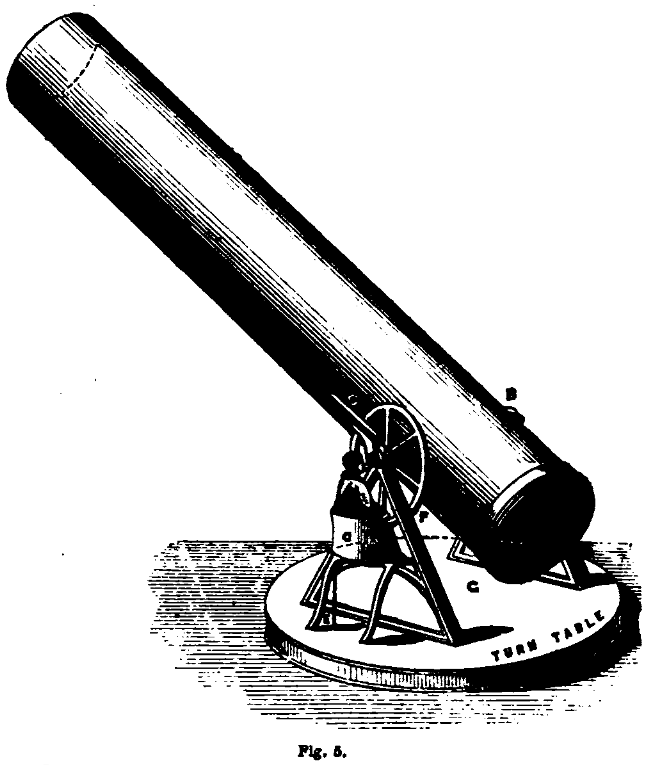


Fig. 5.

Fig. 5 is a perspective view of Mr. Nasmyth's "Comfortable Telescope;" C is a cast-iron turn-table, which, on being moved round, carries with it the entire instrument, and the observer, who, seated in a comfortable chair, has complete control of the elevation and round-about motion; the former by means of a tangent screw and wheel, F, the latter by tangent screw and pinion-shaft, E, which commands the roundabout or azimuth motion. An eye-piece is placed convenient to the eye of the observer at G. Some idea may be formed of the facility with which the movements can be controlled, when it is stated that within two minutes Mr. Nasmyth has frequently directed this large instrument to nine different objects situated in various parts of the heavens.

Mr. Nasmyth, at the request of the president of the Section, gave some description of his mode of securing perfectly sound castings of specula for such large instruments, of which we hope to furnish our readers some account in our next number.

On a Patent Steam Plough. By James Usher.

Mr. Usher described his Patent Steam Plough, and stated that many fruitless attempts had been made to cultivate the land by steam-power, the reason of which had been that the parties had proceeded on an entirely erroneous principle; as, from the method they have pursued, they could never get the machine to proceed along the land. This can be simply explained by stating that all former attempts have gone on the principle, that ploughs must be *dragged* through the earth. Now, if we consider for a moment, it will be seen that the ploughshare and its bearer are exactly similar to a common anchor; which, if thrown into the sea, it will hold the largest vessel fast, much more than a small engine of 10-horse power. To obviate this great difficulty, in the present machine the plough is reversed and made like an anchor, thrown out afore ship, by which the sailor hauls his vessel into position; and thus, instead of making the anchor a power to hold the vessel back, it is here made a power to pull it forward; or, in other words, the plough is inside a paddle-wheel, instead of an anchor cast astern, and thus the carriage is propelled along the land. In thus making the plough a paddle-wheel, the next difficulty was, that five or six ploughs entering the earth at the same time would lift a solid piece of earth, and carry it round; while, to put the ploughs each on a separate axis, would involve such a length of machine that it might not work. To obviate this, all the ploughs are put on the same axis, and each share is placed a little behind the preceding, by which arrangement no two shares come into action at the same moment, and the first set have turned over their given quantity of earth before the next set enter the land.

Fig. 1.

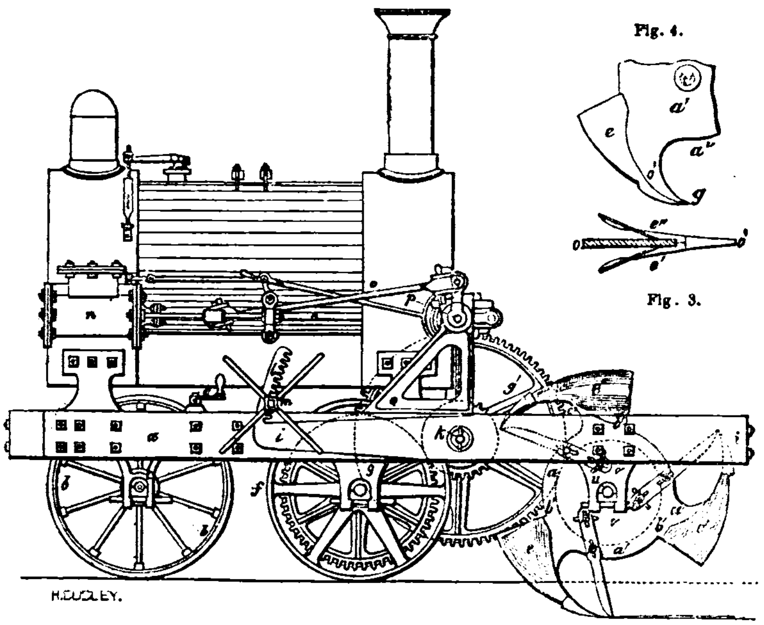
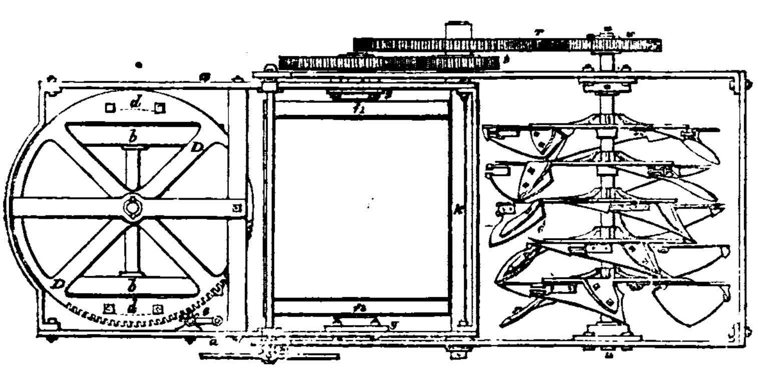


Fig. 4.

Fig. 3.

Fig. 2.



On applying the power of the steam-engine to the ploughs, it was found they ran along the earth without turning it over, and it became necessary to put a drag on the wheels, to prevent the carriage running away from its work; but instead of putting on the common railway drag, it was thought better to connect the wheels of the carriage with the wheel which drives the ploughs. Thus is obtained a uniform stroke for each plough as it enters the earth, and it cannot proceed until it has turned over the desired area. By this it will be perceived the ploughs drive the carriage-wheels at the necessary reduced speed, *the forward motion of the machine being communicated from the plough to the carriage*, instead of from the carriage-wheels to the ploughs, as in many agricultural implements now in use; or, to apply again a former simile, the paddles drive the vessel, instead of the vessel driving the paddles. Mr. Usher then proceeded to show a working model of the plough.

Fig. 1 is a side elevation. Fig. 2 is a plan of the underside. Fig. 3 is a plan of a plough when two mould boards are used, in cases where it is desired to turn the land on either side; and fig. 4 is a side view of one of the ploughs on its axis, by which and by fig. 1 it will be seen that the under edge of the mould board and share is formed to a curve struck from the centre of the shaft or axis on which the ploughs are affixed; *a a* indicate the bed-frame or carriage of the machine. The fore carriage wheels *b b* are mounted on an axle, which turns in bearings *c* attached to the swivel frame D, which moves on the bolts *d* for the purpose of causing the machine to turn round in a small space. A portion of the swivel frame D is toothed, and acted upon by the pinion and winch *e*; the hind-part of the carriage is here shown supported upon the hollow cylinder or roller *f*, composed of two extreme parts, f^1 and f^2, which are wheels similar to *b b*. the intermediate part *f* being by preference removable at pleasure, so as to render these bearing parts suitable to the different stages of cultivation to which the machine may be applied. This compound cylinder has its axle supported in the bearings *g* attached to the lower, or to the under side of the carriage frame. The axle of this cylinder carries also at one end the wheel *h*, to be afterwards noticed.

A moveable lever frame *i, i, i, i*, is supported on an axle or shaft *k*, as a fulcrum. The free ends *i' i'* are formed into the toothed segments *e*, and are concentric to *k*, these segments being acted upon by the two-toothed pinions and spindles *m*, which elevates or depresses the hind part *i i* of the lever frame, and all that it carries, at the pleasure of the conductor.

On the carriage thus constructed is placed the locomotive boiler, with its engines of any ordinary construction, as *n n*, the power of which is applied through the medium of connecting rods *o* to the crank shaft *p*, the two arms of which stand at right angles to each other, in the usual way. The crank shaft *p* is supported on two standards *q* securely fixed to the carriage. On the shaft *p* there is also fixed the spur pinion, indicated by the dotted circle *p' p'* in fig. 1; and this pinion, by taking into the wheel *r*, mounted on the shaft *k*, gives motion at the same time to the pinion *t*, which is carried round on the same shaft *k*. The pinion *t*. thus actuated, takes into the wheel *h*, before referred to, on the bearing cylinder *f*; and it is preferred that the pinion *t* should be applied so as readily to be put into and out of gear with its wheel, though not so shown in the engraving. By this arrangement of parts, a slow progressive motion is obtained for the whole machine, on the one hand through the cylinder *f*, and on the other hand a separate rotatory motion, at a certain increase of speed, is communicated through the wheel *r* to the pinion *w*, fixed upon the pinion *u u*, which last-named shaft has its bearings *v v* attached to the moveable frame *i i*.

On the shaft *u u* are placed a series of plates or projections, fixed at regular distances. Or such plates or projections, with their ploughs afterwards described, may be placed upon separate shafts, each with its own proper gearing; but it is preferred to place them on one shaft. These plates or projections on the axis are shaped in such manner as to receive and have affixed to each of them several ploughs, adapted by their revolving motion to penetrate the soil, and by their mould-boards to elevate and turn over portions thereof; *a a* are the plates or projections fixed upon the shaft *v*; they are each formed with a strong boss at the centre, by which it may be securely fixed to the shaft. Each plate *a'* has three arms or prolongations *b, b, b*, which terminate in the radial direction shown; a further prolongation *d' d'* is carried obliquely upon each of these arms. Upon the plate and projections thus constructed is affixed the tilling apparatus, which consists, firstly, of the part *e'*, which acts the part of the mould-board or turn-furrow in the common plough; and it is to be fixed by screw bolts or otherwise to the prolongations *d' d'*. To the fore part of this mould-board *e e* is affixed a bar *f* of wrought-iron, which is also furnished with a lug *f''*, by which it is attached to the plate, by means of screw bolts or otherwise; the bar *f*, thus secured, forms a head or share bearer, as in many common ploughs. To the fore part of the bar *f*, the share *g* is adapted, and fixed by its socket. The mould-board, and also the share, may be varied in form. A fore-cutter, or coulter *h'* is affixed in front of each share, by screw bolts or otherwise, and is provided with the means of adjustment through the counter slits, in itself, and in the plate; but, in order to meet the different qualities of soils and the various stages of tillage, the further provisions shown in figs. 3 and 4 are employed. Fig. 4 shows a variation in the form of the plate *a* of figs. 1 and 2. *a* is the shaft, as before, carrying the plates or projections; a^1 shows a detached portion of one of these plates, in which the curved part a^2 to a^3 is brought forward and armed with a steel blade, answering the purpose of the separate coulter *k'* in fig. 1; *e* is the mould-board, and *g'* the share, as before. Fig. 3 is a form of plough suitable to the tillage of green crops; *a'* is a portion of the plate or projection, seen edgeways; *e'* and *e'* are right and left mould-boards, and *g'* a plain spear-shaped share. The number of plates or projections, and also the number of ploughs in each, may be varied.

On a Gas Stove. By Mr. W. S. Ward.

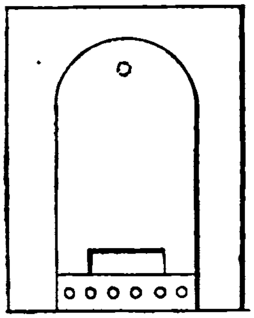


Fig. 1.

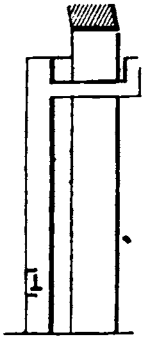
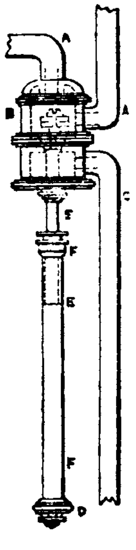


Fig. 2.

The novelty of the stove consists in constructing it of iron plates in a vertical position, so as to expose considerable surfaces for the absorption of heat from jets of gas, and for the radiation of the heat. The author found that his apparatus was sufficient to raise the temperature of a moderate sized room from 5° to 10° Fahrenheit, with a consumption of about three feet of gas per hour, costing about 2*d.* for ten hours; and that it was particularly useful in warming a bed-room, where only a slight elevation of the temperature was required, and free from the production of dirt or smell.

The annexed engraving, fig. 1, is a front view of one of the stoves, and fig. 2 a vertical section; it consists first of a sheet of plate-iron to fill up the usual opening of a fire-place, with a hole through for a chimney, and two other plates of iron placed about three inches apart, and inclosed round the rim; near the bottom are perforations to admit air, and a small door with a burner, consisting of several small jets inside; when the gas is lighted, it heats the air inside, and the surface of the two iron plates; by this arrangement all unpleasant effluvia is conveyed away through an iron pipe that is made near the top, and which leads into the chimney of the room.

Mr. McPherson explained *an Apparatus for preventing Water-pipes bursting by Frost.* The apparatus is shown in the annexed figure, and is acted upon by the expansion of water, just as it is on the point of freezing. Let A represent the supply pipe; B a double-action valve; C the waste-pipe; F a copper tube containing the liquid to be frozen; D, the bracket to support it to an iron plate. Now, if frost acts on the copper tube F, it will expand the water therein, elevate the piston E, and push up the valve B, from its seat, and thereby open a communication with the waste-pipe C, through which the standing water in the pipe A, escapes, and finally shuts against the supply pipe A, thus accomplishing the shutting off the water and emptying the pipes.



A new Method of Supporting the Speculum of Large Telescopes. By Mr. Lassell, of Liverpool.

Mr. Lassell explained by a diagram the method he proposed to construct the speculum of large reflecting telescopes to prevent any sensible flexure. This he proposes to do by casting on the back of the speculum several ribs, and placing an additional plate behind with several perforations, each having a pin or lever supported on centres, when the speculum is placed in a horizontal or inclining position. It is supported by these pins or levers acting against the ledges of the ribs; for a 2-feet speculum he proposes to cast five ribs at the back, and have about eighteen pins or levers to support it.

Mr. Buchanan explained *a new kind of Valve for Waterworks.* It consists of a flexible web made of India rubber strained over a metallic surface, having one or more hollow grooves, or a hollow space. When there is the slightest pressure on the top of the valve, the flexible web completely seals the aperture over which it is placed. The annexed engravings show two examples of Mr. Buchanan's invention fig. 1; A is a valve with a plate having two grooves covered with a web *b* of india-rubber; *c* is a dead plate with a raised rim fixed in the orifice, and *d* is the orifice of a pipe with a knife-like edge. When the valve A is pressed down, the web where the grooves are, is gently pressed against the two edges of the plate *e* and orifice *d*, and closes the aperture. Fig. 2 is another form; the valve A has a hollow plate covered with the web, which, when pressed against the edges surrounding the aperture *c*, completely closes the opening.

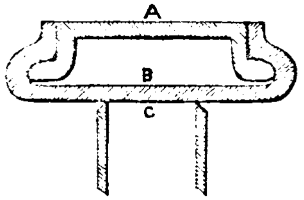


Fig. 1.

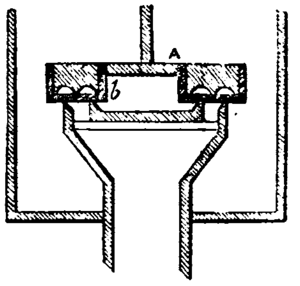


Fig. 2.

On a new and ready Process for the Quantitative Determination of Iron. By Dr. F. Penny.

The author recommends the employment of the chromate and bichromate of potash for the estimation of iron in the common ores of the metal, and especially for the analyses of the clay-band and black-band ironstone of this country. He was led to the application of these salts in the course of some investigations on the materials and products of the manufacture of alum from "alum-shale," in which he was much retarded by the want of a ready method for estimating the oxides of iron. The chromates of potash give very exact results, and possess the great advantage that a much larger quantity of material may be operated on than can be conveniently treated by the usual methods. For practical purposes, he says, the bichromate is to be preferred. The process requires no other apparatus than that commonly used for centigrade testing, which is familiar to all persons engaged in chemical pursuits. It may be easily and rapidly executed, occupying only a fraction of the time required for the process of estimating iron by precipitation as the sesquioxide; and it is not interfered with by the presence of alum and phosphates which usually exists in the ore. The method is based on the well-known reciprocal action of chromic acid and protoxide of iron, whereby a transference of oxygen takes place, the protoxide of iron becoming converted into sesquioxide, and the chromic acid into sesquioxide of chromium.

A Notice of very powerful Magnets made by the process of M. Elias and under his direction, by M. Logemon, Optician, Haerlem. By Sir D. Brewster.

By this process a magnet 1 lb. weight will, with due precaution, support 28½ lb., and the power does not sensibly diminish though the armature be suddenly detached several times. It has twice the power of magnets commonly made in Britain. Magnets capable of raising 400 lb. are made in this way. Sir David exhibited two of M. Elias's magnetic horseshoe combinations of bars, one of about 17 oz. weight, and another of 12½ lb., the latter capable of supporting 150 lb. It was necessary, for their perfect action, to polish the ends of the armature with two pieces of wood covered with emery and lead. The line joining the poles must be as perfectly horizontal as possible. The bars are magnetised by being moved several times through a helix of copper wire, along which the galvanic current passes.

Dr. Scoresby bore testimony to the great superiority of these magnets to similar magnets made by regular magnet makers in this country. But he had, after a series of magnetical investigations (the results of which he had published in 1843) made magnets nearly, if not quite, as powerful as those of M. Elias.

Mr. Hunt had tried magnetising by the coil, and found the best effect to be produced by a blue heat being given to the bar, which at that temperature was exposed to the current, and then plunged into water or a solution of *ferro*-prussiate of potash.

Dr. Scoresby remarked that 500° or 505° was the best heat to which a bar should be raised before being magnetised. Too powerful magnets also ought not to be used in magnetising.

Mr. Ward had had considerable success in magnetising by the coil, by drawing a helix of about an inch in height from the centre of the bar, backwards and forwards, as in the ordinary mode of magnetising.

On a Tubular Crane. By Mr. Fairbairn.—The jib and post of the crane is formed hollow, of boiler plate.

THE INSTITUTE OF BRITISH ARCHITECTS
ON
CEMENTS AND STUCCOES.

It is not often that the Institute of British Architects indulge in æsthetics. Generally speaking, whenever the subject is fairly opened to them by the nature of their lectures, they avert the discussion to a matter of fact question respecting the economical use of slate, the number of feet and inches in a broken column, or some other subject equally well calculated to promote an improved architectural taste.

With surprise and gratification, therefore, we observed that, during the late meetings, the reading of a paper on "Cements and Stucco" (*ante*, p. 221), led to an animated and interesting discussion respecting the legitimate use of those materials. The debate was carried on with far more earnestness of purpose than could be incited by a mere abstract question. No abstract question can long engage the earnest attention of a general assembly, but to the British Architects the inquiry whether the use of deceptive materials be in good taste is not an abstract inquiry. It is a vital question to them; for probably if that question be decisively answered in the negative, it is not too much to assume that the decision would be condemnatory of half the buildings erected by members of the Institute.

Mr. Knowles, the reader of the paper referred to, states the objections against the use of stucco for "protecting and adorning the exterior of our buildings" to be

1. That cements and stuccoes are not durable, and require frequent and expensive reparations.
2. That they are very costly; not so much at first, as by reason of the colouring and painting in oil, which, it is thought (erroneously, as he believes), that they afterwards require.
3. That they are false and deceptive inasmuch as they, being artificially formed materials, do in some measure assume the appearance of natural productions.
4. That their introduction has led to all that is false in design, and defective in construction.
5. That when employed in decoration, the enrichments are deficient in that sharpness of outline and delicacy of finish by which the productions of the chisel are distinguished.

Of the first of these objections he confesses, that it applies with great force to modern London buildings, and that "extreme care" is required "in the construction of buildings intended to be covered with cement." The second objection may, he thinks, be removed by an improved knowledge of chemistry and geology. With respect to the deficiency of sharpness of outline in ornaments moulded in stucco, he asks whether it be not possible to overcome this difficulty by increased attention on the part of the architect in designing, and especially in inspecting the modelling of his enrichments whilst in the clay.

Up to this point we need not demur to any of the arguments in defence of stucco, for they amount to an acknowledgement, that the use of that material involves peculiar difficulties and requires peculiar precautions. But now comes the gist of the debate, the question as to the deceptive nature of the material. Mr. Knowles ingeniously argues, that grandeur, beauty, and originality of design, are far more important and far less easily attainable than costliness and durability of materials.

"That species of admiration which is excited by the costliness of the materials employed in works of art, has always appeared to me to partake considerably of the vulgar and the barbarous. For, as much as the heavens are higher than the earth, so much do I believe the emanations of the mind to be above and beyond the mere vehicle in which they are embodied."

Precisely. We do not happen to know the altitude of the "heavens," but if Mr. Knowles will adopt any kind of terrestrial measure, we have little doubt that we shall be able to assent to his estimation of the superiority of mind above matter. We readily allow that all that is vile and monstrous in taste may be exhibited in an arch of the purest statuary marble or bronze, cast in the most costly manner; while some of the most admirable buildings which have appeared on the face of the earth are churches and castles built of bricks. But who are those most liable to the charge of preferring the material before the design and skill of the architect? Those who would let plain bricks honestly show themselves? or those who would hide the bricks beneath a surface imitating costlier stone? The "admiration excited by the costliness of materials" *does* partake "considerably of the vulgar and barbarous." But can that vulgar and barbarous admiration be exhibited in a more vulgar and barbarous manner than in the concealment of cheaper substances by a mere show and unreal pretence of costliness? Or can that same admiration be more openly and decisively disavowed than by the honest exhibition of the cheaper substances?

Mr. Knowles has, it appears to us, forged a weapon which inevitably recoils upon himself. His gun *kicks* more strongly than it shoots. The very argument which he has chosen for a defence of stucco is its most decisive condemnation. If the admiration of costly materials be barbarous, how infinitely more barbarous is the dishonest imitation of them. If the love of real gems has a vulgar taste, what shall be said of those who wear paste diamonds?

As a matter of practical experience, the use of stucco in domestic architecture leads to the constant re-production of the same insipid forms. Where the ornament can be laid upon a building as something altogether extrinsic and adventitious, the principal necessity for originality and invention is altogether evaded. But where the ornament is an essential and integral part of the building—where it depends upon, and springs out of, the construction, the architect is almost compelled to think whether he will or not; and, on the other hand, where the construction can be wholly hidden by a false surface, on which skin-deep ornaments can be laid at "so much per yard run," ornament becomes mere stock-in-trade, to be kept on hand till wanted, and *the architect is superseded by the builder.*

In the discussion which followed the reading of the paper, it is gratifying to find that architecture was regarded—not as a mere fancy or fashion—nor as a mere code of arbitrary rules—nor as a system of jugglery to delude mens' eyes by false show of splendor—but as a liberal art. Mr. Francis appeared to us to give the *coup de grace* to the question, which the most unfortunate argument above referred to had already settled. Cement he considered "a material quite inadequate for the purpose of minute and elaborate design in ornamental work, which, when executed in it, must want the freedom of touch and the artistic feeling belonging to the chisel. For freedom of touch and artistic feeling, we should as soon look in a willow-pattern plate as in plaster ornaments run in a mould."

It is certainly in too exclusive a spirit that some writers condemn *all* kinds of ornamental forms multiplied by mechanical means. Such condemnation is far too general. It would include *engravings* which have a beauty and excellence of their own, differing much from that of the pictures from which they are taken. To engravings, moreover, is incontestibly due the merit of popularising the highest works of the easel. But an engraver must be an artist, and have an intellectual feeling of the spirit of his original; while the maker of stucco ornaments is a mere mechanical drudge, an Irish labourer, probably, who has never cultivated his taste beyond an appreciation of gin and tobacco. The engraver must have a wonderfully keen eye for all the varying depths of different colours which have to be imitated by him by mere gradations of shade in black and white.

Even where mechanically produced, decorations require no taste for their successful reproduction, they may yet possess grace when honestly and legitimately employed. Such grace may and ought to belong to paper-hangings, the forms of porcelain, and glass utensils, and the patterns of the commonest and cheapest pottery. *Such grace may also belong to ornaments of plaster properly employed.* To confine ourselves to one instance among many, it would be, we think, mere architectural puritanism to object to the adornment of ordinary ceilings with appropriate decorations in stucco. In such use of plastic materials no deception could be intended or effected. The white plastered ceiling of an ordinary room can no more be mistaken for stone than ordinary gilding for gold.

The real offence against taste is the attempt to deceive. Gilding is a most admirable and beautiful species of decoration when legitimately employed; but when used where it passes for solid gold, it is the display of the vulgarest pretence. The similar observation applies with regard to stucco. As Mr. Donaldson unanswerably observed, "the jointing given to cement in order to make it imitate stone, produces evidently a false appearance." It is a mere perversion of truth to say that no deception is meant in stucco-covered buildings, when pains are taken to score horizontal and vertical lines in imitation of the courses of masonry. How preposterous to allege that such a miserable expedient is not an attempt at deception! It has all the dishonesty of a juggle without its cleverness.

We would be almost content to leave the question on this single issue. When the admirers of stucco came to score upon it the lines aforesaid, we will charitably try to hope that they intend no deception. But, until that be done, they will remain under the imputation of using a false substance to hide—not the poverty of materials—but, far worse, poverty of invention.

If we turn from mere speculation to the evidence of history, it is instantly apparent that those periods in which materials have been used honestly and faithfully, have been those least subject to that pest of architecture—copyism. The Greek temple, formed of solid blocks of stone was a purely original idea, entirely different from all preceding forms of architecture. The massive structures of Egypt and ancient Rome, with all their faults, bore the impress of unmistakeable originality. Of the exhaustless fertility of invention, and the endless prodigality of design exhibited by our Christian ancestors, it is impossible to speak adequately. The proud Minster, the humble village Church, the impregnable Castle, and the graceful Hall, have each a distinct character of its own. But in our own time, all originality of design seems abandoned, or left to those few architects who build honestly. In domestic architecture, the highest effort is the reproduction of a well-known Italian façade, with a few slight variations, or the decoration of a building (of which the flat surface and vast rows of windows identify it *in construction* with a cotton-mill) with the endless repetition of heraldic devices and innumerable weathercocks. Ordinary architecture is worse even than this; for the new streets and charming villas which spring up like fungi about the metropolis, are generally more hideous than their vegetable types. It is a comfort to think that their defective construction promises an almost equally rapid decay.

We are earnest in the discussion of this question, and are willing to be charged with harping on one string till it is effectually set at rest, for we reckon among the most cheering signs of the progress of architecture, that those who debated the question at the Institute of British Architects were almost unanimous against the use of false materials. That pernicious system which inflicted on us the gew-gaw splendour of Georgian taste, has too long cramped the energy and spirit of modern architects. The first promise of their emancipation from the insipid traditions of the last century, is coeval with the revived study of Pointed Architecture, a style which nobly evidences, that in building as in morals, *it is good to be honest and true.*

THE GREAT EXPLOSION AT SEAFORD.

There was a blasting upon a large scale at Seaford on Thursday, 21st ult., for the purpose of throwing down a considerable portion of the chalk cliff on to the beach, for checking the progress of the shingle towards Beachy Head and the East.

Seaford is situated close to the eastern extremity of a bay three miles in length, extending from Seaford Head to Newhaven Head. It is one of the Cinque Ports. It is twelve miles from Brighton and about five from Beachy Head. Close to the sea is a Martello tower—the last westward; there is also a fort, which is under the care of a resident master gunner. But the ground about Seaford for two miles to the west lies low, and there is nothing to protect it from the inroad of the sea at high tides but a narrow beach bank of shingle. This barrier is becoming gradually weaker in consequence of the tendency of the shingle to drift away, and it has become a matter of urgent moment that this should be stayed. Close to Seaford, on its eastern side rises a noble line of cliff, in some places 300 feet high, and averaging above two hundred. It was determined to project a huge slice of the cliff to the beach, with a view thereby to constitute a groin for the purpose of retaining the shingle and preventing its leaving the bay. The operations have been conducted by the Board of Ordnance, but the owners of land about Seaford contribute towards the expense. The works were begun about seven weeks ago, and there have been 55 men of the Royal Sappers and Miners engaged upon them.

The spot selected for the operation is not much above half-a-mile to the east of Seaford. At a height of about 50 feet above high-water mark there was driven into the cliff or excavated, a tunnel or gallery 70 feet long, 6 feet high, 5 feet broad, ascending with a slope of 1 in 3. At the inland extremity it turned right and left in the heart of the cliff, above 50 feet one way and above 60 the other, with a more gentle ascent, the two smaller galleries being 4 ft. 6 in. high, and 3 ft. 6 in. broad, and the three being in the form of a capital T. At the utmost end of each of the side or cross galleries was a chamber, 7 feet cube, lined with wood; and in each chamber a charge of no less than 12,000lb. of gunpowder was deposited; making the distance of the centre of the charge 70 feet from the face of the cliff towards the sea, and about 70 feet above high-water mark. The galleries were "tamped," that is stopped up with bags of sand, and chalk in bags and loose, to within 50 feet of the mouth, both branches being tamped up, and 20 feet down the large gallery. The tamping is, of course, a very important matter; the hole through which the charge of powder is deposited should offer more resistance to the force of the exploded powder than the solid earth, in order that the powder may not find vent through that entrance, but spend its power upon the earth to be cast up; and this may be the better accomplished where the firing is by voltaic battery, because there is only a thin wire to pass through the tamping for the purpose of ignition. It must be added here, that above this charge of powder, and on the top of the cliff, three shafts or pits were sunk to the depth of 41 feet, and 600lb. of gunpowder deposited at the bottom of each; these pits were tamped with chalk. Very near these pits—perilously near it almost seemed—about 180 feet from the edge of the cliff, a small wooden shed was erected, in which were placed three voltaic batteries, two of Groves's and one of Smee's, for firing the charges; the wires to convey the electric fluid to each charge were covered with tape and varnished or tarred over; the wires to the two lower charges in the chambers were of course, carried over the top of the cliff. It was arranged that these two great charges should be fired simultaneously, and the three above a few moments afterwards.

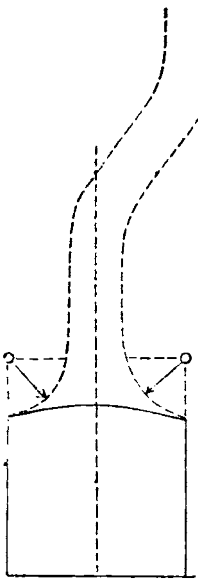
It was at twelve minutes past three o'clock, p.m. that suddenly the whole cliff, along a width or frontage of some 120 feet bent forwards towards the sea, cracked in every direction, crumbled into pieces, and fell upon the beach in front of it, forming a bank, down which large portions of the falling mass glided slowly into the sea for several yards like a stream of lava flowing into the water. The whole multitude upon the beach seemed for a few moments paralysed and awe struck by the strange movement, and the slightly trembling ground; every one sought to know with a glance that the mass had not force enough to come near him, and that the cliff under which he stood was safe. There was no very loud report; the rumbling noise was probably not heard a mile off, and was perhaps caused by the splitting of the cliff and fall of the fragments. There seemed to be no smoke, but there was a tremendous shower of dust. Those who were in boats a little way out state that they felt a slight shock. It was much stronger on the top of the cliff. Persons standing there felt staggered by the shaking of the ground, and one of the batteries was thrown down by it. In Seaford, too, three quarters of a mile off, glasses upon the table were shaken, and one chimney fell. At Newhaven, a distance of three miles, the shock was sensibly felt.

In a few moments after the cliff had fallen the crowd upon the beach rushed forward to it. A second fall of chalk, when they had got about half-way, checked them for an instant, and but for an instant. They rushed up the mound which the exploded chalk had formed. Although it is a mass of large rough stones for the most part, difficult in many places to climb except by using one's hands as well as feet, yet ladies eagerly clambered up it, and one gentleman managed to get his horse up. It will probably, like the cliff still standing, be rather unsafe for a time, as there is reason to believe that further falls will follow, considerable masses which have not yet fallen being evidently loosened. The mass which came down on Thursday is larger than was expected; it forms an irregular heap, apparently about 300 feet broad, of a height varying from 40 to 100 feet, and extending 200 or 250 feet or more seaward, which is considerably beyond low-water mark. It is thought that it comprises nearly 300,000 tons. The operation is considered to have been decidedly successful.

The work was under the direction of Sir J. Burgoyne, Inspector-General of Fortifications, but the immediate direction was taken by Captain Frome; Lieutenant Ward, R.E., had charge of the voltaic batteries. Colonel Lewis, Lieutenant Greatorex, and Lieutenant Crossman, assisted in the operations. Sir J. Rennie and a number of civil engineers were on the ground. Sir C. Pasley was present, and, as we understood, the Duke of Beaufort and

Lord F. Fitzclarence; as also was Mr. Wright, C.E., who conducted the operations at the blasting of Rounddown Cliff, near Dover; and Colonel Sandham, Sir H. Shiffner, and other gentlemen of eminence.

SMOKY CHIMNEYS.



Sir—If the following mode was adopted in building our fire-place openings and flues, we should require a much less number of those incongruous inventions at the tops of our chimneys, disfiguring as they do the sky-line of our houses. It has been successfully adopted by Mr. Pierce, of Jermyn-street, and ought to be generally known.

His plan is to fill-in the openings of old chimneys, and in building new ones, to contract them quickly though gradually, by means of a *convex gathering*, in contradistinction to the *concave*, which was formerly much in use. (It forms a quicker draft, and is not a receptacle for cold air, as the latter is.) I have tried it, and think it due to Mr. Pierce to say that it has fully answered. The diagram will illustrate it practically. The more perpendicular and central the flue is carried up for the first two or three feet before gathering over on either side, the more efficient will it be found. Let all bends be very easy, the flue of uniform size, with sound construction, and the fire-place openings proportionate to the size of the rooms.

I should observe that, gathering the flues over all in one direction, without returning them in an other, is now exploded. It is found to be quite immaterial as to where the flues go, provided all bends are easy.

John Burges Watson.

39, *Manchester-street*, *Manchester-square*.
Sept, 24*th*. 1850.

BUILDING BRIDGES IN THE AIR.

The Academy of Sciences has at present under consideration a plan of a most extraordinary character, being neither more nor less than a suspension bridge between France and England. M. Ferdinand Lemaitre proposes to establish an aërostatic bridge between Calais and Dover. For this purpose he would construct strong abutments, to which the platform would be attached. At a distance of 100 yards from the coast, and at distances of every 100 yards across the Channel, he would sink four barges, heavily laden, to which would be fixed a double iron chain, of peculiar construction. A formidable apparatus of balloons of an elliptical form, and firmly secured, would support in the air the extremity of these chains, which would be strongly fastened to the abutments on the shore by other chains. Each section of 100 yards would cost about 300,000f., which would make 84,000,000 for the whole distance across. These chains, supported in the air at stated distances, would become the point of support to this fairy bridge, on which the inventor proposes to establish an atmospheric railway. This project has been developed at great length by the inventor.

Rhine Bridge.—It appears from an official document published by Mr. Van der Heidt, the Minister of Trade and Public Works, that the committee appointed to examine the merits of the various plans for a bridge over the Rhine, between the cities of Cologne and Deutz, have awarded the first prize of 250 frederics d'or to Mr. John W. Schwedler, architect, of Berlin, and the second prize of 125 frederics d'or to Captain Scarth William Moorsom, of London, the engineer. There were several English competitors, among others Mr. Fairbairn.

ON GALVANIC SOLDERING.

In the 'Technologist' M. Elsner gives an account of some experiments he has made on galvanic soldering. Under the name of galvanic soldering, a process is known by means of which two pieces of metal may be united by means of another metal, which is precipitated thereon through the agency of a galvanic current. This mode of soldering by the "wet method" has been often recommended in various periodicals relating to the industrial arts; but it has been objected that—practically speaking—the union between two pieces of metal could not be effected by means of a metal so precipitated by galvanic agency. In order, however, to arrive at a definite conclusion upon this question, M. Elsner undertook thefollowing experiments, making use of a Daniell's "constant battery." The first experiment he made was by placing upon the end of the copper wire, which formed the negative electrode, a strong ring of sheet copper, cut asunder at one point, the distance between the severed parts being about one-half or one-third of a millemetre, and immersing it in a bath of sulphate of copper. At the end of a few days (during which time the exciting liquors were several times renewed) the space in the severed portion of the ring was completely filled up with copper regulus, which had been precipitated; and on partially cutting with a file through the part thus filled up, and examining it with a lens, it was observed to be very equally filled with solid and coherent copper. A second experiment was made with another copper ring cut into two parts, and the two segments placed with the faces of the sections opposite each other, and similarly submitted to the action of a galvanic current. At the end of a few days the segments were united by the copper precipitated, and again formed a complete ring. A third experiment was made by placing two strong rings of sheet-copper, with their freshly-cut faces upon one another, so that the two rings constituted a cylinder. These rings were surrounded by a band of sheet-tin, coated with a solution of wax, so that the two rings were equally surrounded by a conducting material. The rings were then attached to the negative wire of the battery, and immersed in a bath of sulphate of copper. At the end of a few days the interior surface and the contact surfaces of the two rings were covered with precipitated copper. The rings were only submitted to the galvanic current to such an extent as to cover their interior surface with a thin coating of precipitated copper, and yet they were so completely re-united that they formed a single cylinder. The exterior conducting covering of tin was, of course, removed, before testing the cohesion of the galvanic precipitate.

From these experiments, there appears to be no doubt that two pieces of metal may be firmly united or soldered by galvanic agency. It will, therefore, be possible to firmly unite the different parts of a large piece of metal, and to make a perfect figure of them by galvanic precipitation of a metal (copper in ordinary cases.) If solutions of salts of gold or silver were employed in as concentrated a form as those of copper above-mentioned, there is reason to believe that galvanic soldering would also result. In fact, M. de Hackewitz states, that in some experiments on a larger scale, which he undertook, to obtain hollow figures by galvano-plastic means, he had remarked that galvanic union often took place between the pieces operated upon. M. Elsner states, that while conducting the experiments above-mentioned, he remarked that, by employing too powerful a current, the negative electrodes of copper, and even the plate of copper, and ring of the same metal resting thereon, became covered with a deep brown substance, in the same manner as this occurs under similar circumstances in galvanic gilding, as is well known. After several unsuccessful attempts to prevent the formation of this brown coating, M. Elsner found that it was possible to remove it entirely on immersing the articles covered therewith, during a few seconds, in a mixture of sulphuric and nitric acids. By this means the precipitated copper was made to assume its natural red colour.

With respect to the cohesion of the galvanic soldering, it is the same as that of copper or other metal precipitated by galvanic agency. It will, moreover, be well understood, that too energetic galvanic excitation must have an injurious influence upon the cohesion of the metal precipitated; and in this case precisely the same phenomena will be observed as those which have long manifested themselves in ordinary galvano-plastic operations.

THE QUARRY OF THE LIVERPOOL DOCKS.

Kilmabreck Quarry is the source whence all supplies of granite blocks and paving stones for the Liverpool Dock Quays are derived. Kilmabreck is situate near Blackcraig, in Galloway, and has of late years become a place of some importance. The quarry was opened about twenty years ago; and the clergyman of the parish gives the following interesting description of the *modus operandi*:—"The working of this quarry, in 1834, cost nearly 15,000*l*., including rent and tonnage of vessels, &c. It is wrought in three breasts, about 30 feet high each, the one above and behind the other. The operations are conducted with much skill and regularity. At one time powder was very much employed in this work; fifty, sixty, and as high as seventy pounds were used in one blast. These explosions were felt and heard at a considerable distance, as the slight shocks of an earthquake. The use of powder, however, except in opening up corners, has been for some time entirely given up. Blasting was found to shake and frequently to destroy some of the finest blocks. Drills, wedges, crowbars, sledge-hammers, and cranes, are now principally used in quarrying even the largest masses; and it is truly astonishing to see with what facility even mountains can be removed by *handicraft*. In the quarry the rocks are stratified. The strata are perpendicular, and vary in thickness from nine inches to five feet. When a mass is to be separated, wedges are introduced between the strata, and are driven down with sledge-hammers until a separation is effected. A large crow-bar, well manned, is then applied, to throw down the mass to the bottom of the quarry. This accomplished, the next thing is to cut up the stone into blocks as large as the materials will admit of; and this part of the work is, perhaps, the most interesting process of the whole. The rude and unshapely mass may be five feet thick, and ten or twelve feet long, and must be cut into the form of a parallelogram, to fit with mathematical precision in its own appointed place in the docks. Holes are bored four or five inches deep, with a drill or jumper, and eight or nine inches apart, in the line the stone is to be split. A block of fourteen tons is soon cut to the size and shape required by the power of 'the plug and feather.' When a hole has been bored of the required depth, two wedges are introduced into the hole, with the thick end down, and by driving the one down into the centre, the combined power of three wedges is thus obtained, and made to bear upon every hole, and thus split the stone. A few holes charged with plug and feather will be found sufficient to split a very large stone. In splitting granite in this way, the quarrymen are careful to place the holes and the wedges parallel with the reed or grain of the stone. This arrangement renders the process comparatively easy; and the skilful workmen can shape their blocks and paving stones with as much comfort as if they were cutting wood in a saw-mill. As a proof of the extraordinary power of the "plug and feather," it may be stated, upon the authority of the present skilful overseer, that masses of 500 tons are sometimes lifted or removed by their aid. There is a comparatively narrow ridge of granite rock running parallel with the shore from Creetown to the entrance of Fleet Bay, and which is probably connected with the great mass of the same formation of which Cairnsmore forms the western side, though divided on the surface by a stratum of greywacke. The situation of the quarry has thus been well chosen; for the blocks, when cut and shapen, are transported by a short railway to the shore below, and there shipped in vessels belonging to the Dock Trustees, who have a little fleet of what are called "stone boats." continually sailing betwixt Wigtown Bay and the Mersey.—*Liverpool Chronicle.*

ON FARM BUILDINGS.

A very valuable improvement has been lately suggested in the erection of farm buildings, that the whole area be roofed over like the terminus of a railway. This idea is very little known, and will, no doubt have to contend with much opposition. It will protect the animals, prevent the heavy rains from injuring the dung, and protect the manure from being dried on the surface by the hot suns of the early summer. For such roofs, corrugated iron is the most proper, as its own strength will stand over a moderate width, and it does not require any supporting substance on which to be laid. The asphalted felts are combustible, and require an under roof, on which they are fixed, and on both these points they are inferior to the corrugated iron. The three wings of the farmery will be roofed over with the thin iron, at the common elevation. In covering the width of 20 feet over walls, three rows of roofing will cover the interior of the farmery, and may range north and south, and will rest on cast-iron pillars, which are placed in the subdivision walls of the feeding yards. The roofing can extend over the rickyard and the railway, and place all under one roof. If agriculture would look to the mighty, and at the same time the very convenient joint performances of machinery and railways, it would quickly perceive that many useful modifications of their utility might be introduced into the practical operations of its own departments. It may be very reasonably proposed, that all the articles of agricultural produce, which are changed in form for the purpose of being used, should be placed on the second floor of the farmery, or carried to it, and hence let down in the prepared form in the places where they are wanted. When it is preferred to cut the turnips into slices and the hay into chaff, and when the incontestible improvement comes into use of cutting all straws that are used for litter—then it is evident that all the articles in the crude form must be placed on the higher floor, and descend from it in the prepared condition. In the improved use of threshing machinery, the unthreshed grain is raised from the ground-floor to the feeding board by means of a travelling carrier that is driven by the machinery; or it may be carried from the ricks to the second floor on a high railway, that is placed to the necessary height. The grain from the ricks is laid upon a light wagon, which runs upon the railway to the feeding board The power of steam will drive machinery to almost any extent; and cutters may be placed on both sides of the engine for the purpose of cutting the straw, hay, and roots. The straw may be taken as it falls from the shakers, and put into the adjoining cutters of the kind to cut it into lengths of 3 or 4 inches for the purpose of litter. The hay may be cut into chaff by cutters closely adjoining. On the other side of the engine the roots may be cut by a similar application; and can be raised to the box of the knives by a narrow travelling carrier from the ground floor, and in quantity as the cutters are able to manufacture. The cut food may be laid in stores, whence it can be carried in light wagons on railways to the required places, and let down in spouts. The railways for this purpose must run to the necessary positions for feeding cattle and horses, and for strewing litter over the yards. It is a good thing to have a railway on the ground between two rows of ricks, on which a wagon conveys the grain to the lower floor of the barn, whence a travelling carrier raises it to the second floor, where the machinery receives it to be scutched. A suggestion not much different, places the railway between the rows of ricks on cast-iron pillars, that stand at the height of the second floor of the machinery, and on which the grain is carried by a wagon to the feeding board. A third idea may be published, that the ricks of grain stand singly on four-wheeled platforms resting on a branch railway at a sharp angle of divergence with the main trunk, which leads to the threshing barn. When the rick is wanted to be threshed, the platform is run along the railway which inclines gently to the barn, where an outside shed receives the rick under cover from rain, during the time of threshing. The barn stands across the railway, and receives the rick without the labour of turning such a heavy body to a cross direction. The platforms are returned to the position on the branch railway, in order to receive a rick of the next year's growth. The ricks and machinery are covered by the corrugated iron roof of the farmery extending over them. The suggestion of having a second floor over the entire area of farm buildings, on which to perform all the manufacturing work in the preparation of the different articles for use, may be reckoned a chimera, or a wild sally of the imagination, and with it will be classed the idea of placing each rick of grain upon a four wheeled platform, and running them entire to the barn, as each may be required to be threshed. But from a due consideration, there certainly appears nothing improbable in the feasibility of its adoption, and nothing impossible in the application and execution of the various parts of the composition. It is only an extension of the principle that has already been used on a minor scale and for smaller purposes.—*Gardeners' Chronicle.*

NOTES OF THE MONTH.

New Port in the Mediterranean.—The *Constitutionnel* contains the following:—"Bastia is the wealthiest and most populous town in Corsica. Situated opposite to the Gulf of Genoa, within a few hours' journey from the coasts of Italy and France, on the road to the Adriatic, Sicily, and the Levant, it has become the most important centre of traffic in the country; and of itself possesses one-fourth of the navy. Struck with this importance and with the insufficiency of the old port, the government applied for a credit of 3,000,000f., with the addition of a subvention of 500,000f. furnished by the town of Bastia for the construction of a new port. The works are now in active progress. The port will be of vast dimensions. It will inclose a surface of more than 12 hectares (26 acres), one-half of which will present a depth of 6 metres (19 feet), and of which 2 hectares at least will afford a depth of more than 8 metres (26 feet). A mole in the direction of north to south will shelter the port on its widest side. A refuge will thus be created from the most dangerous storms of those seas, not only for trading vessels of the largest tonnage, but also for the war navy, an important result upon a coast which, for an extent of 40 leagues from the Cape Corse to Porto Vecchio does not afford a single harbour of refuge."

Railway Station.—Although there is a station at Chester 1000 feet long, and which cost 100,000*l*., defrayed by four companies, the London and North-Western have decided upon a separate establishment in consequence of the annoyance and litigation attendant upon their present locale. A deputation of the directors has chosen the site, and plans and estimates are being prepared. We have not heard whether Mr. Philip Hardwick is to contribute the architectural features, but we presume they will be under his charge as the Company's architect.

Heating Horticultural Buildings.—The following is recommended as an economical, efficacious, and simple mode of heating:—"I have been contriving a furnace, with a brick flue four-brick high and sixteen feet in length. This is covered over with tiles an inch and a half thick. The other part of the flue is continued with bricks on edge, covered over with common tiles on the top of the flue; I have made a trough or gutter for the water to flow in. The apparatus is fixed in the furnace containing only five quarts of water, but the trough or gutter will hold twenty gallons, which I find gives a very powerful heat, and will maintain the heat a considerable time, which is a great consideration in cold weather. There is no boiler or iron pipes or tanks used in this plan. The furnace is so constructed that any old cinders will keep a good fire. The Polmaise system can be used at the same time, but I don't want it. This is not upon a large scale, as the flow and return trough or gutter is only about forty feet. It is only the simplicity of the plan which induces me to forward you the above short sketch."—J. D.—*Gardener's Journal.*

Gas Bath.—The gas baths constructed by Messrs. Defries and others, are now attracting much attention, as affording the ready means for architects and builders to provide bath accommodation in private houses, for which there is a growing demand on the part of tha public. With the cheap supply of gas throughout the country, many new domestic arrangements will be made, particularly simple means of cooking in summer time; and in large establishments gas cooking apparatus is likely to be applied, as giving great power in a small space.

The Railing for the British Museum.—A report is current that, the iron railings for the extensive front of the new buildings of the British Museum are to be cast in France. The reason for this is said to be the admiration which is justly expressed for the iron railings in front of Mr. Hope's house in Piccadilly, which were made in Paris, and which are distinguished for sharpness and fineness in casting. It is, however, extremely unjust to rate French casting above English on this account. Mr. Hope's railings cost upwards of thirty shillings per cwt.; whereas the common contract price under competition for similar work in England is twelve shillings per cwt.; and it is with work of this price that Mr. Hope's rails are compared. Let the trustees of the Museum offer even two-thirds of the price that was given by Mr. Hope, and they will find plenty of English manufactures who will produce railings quite equal to the fancy-price foreign article in Piccadilly.

Portsmouth.—Another dock, the ninth now in this dockyard, was added on the 24th ult. to this establishment. The dock was opened at noon by the floating in of H.M.S. *Neptune*, of 120 guns, in the presence of a very large concourse of officers and visitors. This addition renders Portsmouth more complete for dock accommodation than any other naval establishment. The following are the dimensions of the structure:

	ft.	in.
Length from the centre of the caisson grove to the head	306	0
Breadth of the floor	86	0
Breadth between the coping	92	0
Breadth of the entrance	55	0
Depth from the coping to the floor	26	4
Depth of the dock	27	0

It is built of Cornish granite upon a pile foundation, and framed grillage brickwork on cement under the floor. The following are the chief items used in its construction:

Fir timber, in piles and sleepers, 54,500 cubic feet.
Wrought and cast-iron, 98 tons.
Concrete, 9,300 cubic yards.
Bricks, 2,972,000.
Granite, 122,000 cubic feet.
Purbeck stone, 14,000 cubic feet.
Portland stone, 38,000 cubic feet.

Capt. James, R.E., and Mr. H. Wood, clerk of the works, are the officers under whose superintendence the dock has been built, which adds another to the several national works contracted for by Mr. B. Bramble, the mayor of Portsmouth.

Hartlepool.—The annual meeting of the Hartlepool West Harbour and Docks Company was held at West Hartlepool, on the 5th. The report referred to the proceedings in the last session of parliament, and to the act obtained for powers to enlarge the West Harbour, by so altering the piers and enclosing a further part of the sea shore as would give an additional space of nineteen acres. The proprietors readily resolved upon commencing these works, and completing them with all practicable expedition. The West Harbour will then contain an area of about forty-four acres, and will be the largest pier harbour between London and Leith. It will be capable of sheltering 200 to 300 ships, in addition to the accommodation afforded by the two docks, which will contain about twenty acres. The works of the second dock were reported to be in a very forward state, the excavation being more than half finished, and about two-fifths of the dock walls completed. The new town of West Hartlepool, surrounding the West Docks, is progressing very rapidly, the company having sold land for about 260 houses within the last ten months. It is calculated that after deducting a moderate valuation of the land available for resale, the total expenditure on all the works will be about 300,000*l.*, which will represent an undertaking consisting of a harbour of about forty-four acres, two docks of about twenty acres, together with all the land specially appropriated for them, and shipping staiths, approaches, quays, dock and merchants' offices, and various other buildings and working stock and establishment.

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM AUGUST 22, TO SEPTEMBER 26, 1850.

Six Months allowed for Enrolment unless otherwise expressed.

William Dick, of Edinburgh, professor of veterinary medicine, Veterinary College, Edinburgh, for improvements in the manufacture of steel and gas.—August 22.

Benjamin Rotch, of Lowlands, Middlesex, Esq., for a factitious saltpetre, and a mode by which factitious saltpetre may be obtained for commercial purposes.—August 22.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in refining gold. (A communication.)—August 22.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in the construction of ships' magazines. (A communication.)—August 22.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in machinery or apparatus for producing ice, and for general refrigerating purposes. (A communication.)—August 22.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in the construction of ships or vessels, and in steam boilers and generators. (A communication.)—August 22.

Daniel Illingworth, of Bradford, Yorkshire, worsted spinner, for certain improvements in machinery for preparing all descriptions of wool and hair grown upon animals, for the carding, combing, and other manufacturing processes.—August 22.

Duncan Bruce, of Paspebiac, Gaspe, Canada, but at present at Liverpool, Lancaster, Esq., for certain improvements in the construction of rotary engines.—August 22.

Richard Prosser, of Birmingham, civil engineer, for improvements in supplying steam boilers with water, and in clearing out the tubes of steam boilers.—August 22.

Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for improvements in cutting types and other irregular figures. (A communication.)—August 29.

George Augustus Huddart, of Brynkir, Caernarvon, Esq., for certain improvements in the manufacture of cigars, and certain improved apparatus for smoking cigars.—August 29.

Sir John Scott Lillie, Companion of the most Honourable Order of the Bath, of Paris, France, for certain improvements in the application of motive power.—September 5.

John Saul, of Manchester, cotton spinner, for certain improvements in machinery or apparatus for spinning and twisting cotton and other fibrous substances.—September 5.

George Smith, of Manchester, engineer, for certain improvements in steam-engines, and also improvements in feeding or supplying the boilers of the same, part or parts of which improvements are also applicable to other similar purposes.—September 5.

William Watt, of Glasgow, North Britain, manufacturing chemist, for certain improvements applicable to inland navigation, which improvements or parts thereof, are also applicable generally to raising, lowering, or transporting heavy bodies.—September 5.

Andrew Barclay, of Kilmarnock, Ayr, North Britain, engineer, for improvements in the smelting of iron and other ores, and in the manufacture or working of iron and other metals, and in certain rotary engines and fans, machinery, or apparatus as connected therewith.—September 5.

William Erskine Cochrane, of Cambridge-terrace, Regent's-park, and Henry Francis of Princes-street, Rotherhithe, for improvements in propelling, steering, and ballasting vessels, in the pistons of steam-engines, in fire-bars of furnaces, and in sleepers of railways.—September 5.

Frederick Woodbridge, of Old Gravel-lane, Middlesex, engineer, for improvements in machinery for manufacturing rivets, bolts, and screw blanks.—September 5.

John Beattie, of Liverpool, engineer, for certain improvements in steering vessels.—September 5.

James Mather, the younger, of Crow Oaks, Pilkington, Lancaster, bleacher, and Thomas Edmeston, of the same place, calenderman, for certain improvements in machinery or apparatus for scouring, finishing, and stretching woollen, cotton, and other woven fabrics.—September 5.

Christopher Cross, of Farnworth, near Boston, Lancaster, cotton spinner and manufacturer, for certain improvements in the manufacture of textile fabrics; also in the manufacture of wearing apparel and other articles of textile materials, and in the machinery or apparatus for effecting the same.—September 5.

James Rennie, of Goward Bank, Falkirk, Stirling, Scotland, gentleman, for a certain improvement or improvements in the construction of gas retorts and furnaces, and in apparatus or machinery applicable to the same.—September 5.

Pierre Erard, of Paris, for improvements in the construction of pianofortes.—September 12.

Robert Langdon, the younger, of Derby, glove manufacturer, and Thomas Parker Tabberer, of Derby, manufacturer of elastic fabrics, for improvements in the manufacture of looped fabrics.—September 12.

Astley Pasteo Price, of Margate, Kent, chemist, and James Heywood Whitehead, of the Royal George Mills, Saddleworth, near Manchester, for improvements in filters.—September 12.

Thomas Lucas Paterson, of Glasgow, North Britain, manufacturer and calico printer, for certain improvements in the preparation or manufacture of textile materials, and in the finishing of woven fabrics, and in the machinery or apparatus used therein.—September 12.

Richard Archibald Brooman, of the firm of J. C. Robertson and Co., of Fleet-street, London, patent agents, for improvements in purifying water, and preparing it for engineering, manufacturing and domestic purposes. (A communication.)—September 19.

Henri Jeremy Christen, of Paris, engraver, for improvements in cylinder printing.—September 19.

Jasper Wheeler Rogers, of Dublin, civil engineer, for certain improvements in the preparation of peat, and in the manufacture of the same into fuel and charcoal.—September 19.

William Eccles, of Walton-le-dale, Lancaster, cotton spinner, for certain improvements in looms for weaving.—September 19.

Samuel Brisbane, of Manchester, pattern maker, for certain improvements in looms for weaving.—September 19.

John Nasmyth, of Patricroft, Lancaster, engineer, and John Barton, of Manchester, copper roller manufacturer, for certain improvements in machinery or apparatus for printing calicoes and other surfaces; and also improvements in the manufacture of copper, or other metallic rollers to be employed therein, and in the machinery or apparatus connected with such manufacture.—September 19.

Henry Houldsworth, of Cottage House, Lanark, North Britain, iron-master, for improvements in the manufacture of iron and other metals.—September 26.

Alfred Vincent Newton, of Chancery-lane, mechanical draughtsman, for improvements in dyeing yarn, &c., in manufacturing certain woven fabrics. (A communication.)—September 26.

LECTURES ON THE HISTORY OF ARCHITECTURE,

By Samuel Clegg, Jun., M.I.C.E., F.G.S.

Delivered at the College for General Practical Science, Putney, Surrey.

(PRESIDENT, HIS GRACE THE DUKE OF BUCCLEUCH, K.G.)

Lecture X.—ROME.

Roads—Aqueducts—Fora—Basilicæ—Amphitheatres—Circi Theatres—Thermæ—Triumphal Arches.

Dionysius of Halicarnassus says, that "of all the monuments of Rome, the three that appeared to him the most to proclaim the power and magnificence of Rome, were the great roads, the cloacæ, and the aqueducts." In the two former works, the Romans only imitated the example of their Etruscan teachers, though they carried them out to an extent commensurate with the vastness of their dominion. The Roads, or Viæ, traversed, like great arteries, all the provinces of the empire; extending from point to point in nearly a straight line, regardless of "engineering difficulties." Mountains were tunnelled, and magnificent bridges thrown across the widest rivers. The bridge constructed over the Danube by command of the Emperor Trajan, consisted of twenty arches, each 170 feet span; the piers were 150 feet in height from the foundation, and the roadway 60 feet in width. Eight bridges led across the Tiber to the different roads out of Rome. The bridges were frequently decorated with niches and statues in the piers, and often were entered through triumphal arches, or protected by towers. In forming the roads, after the ground had been properly levelled, a mixture of small stones and puzzolano was laid to a certain depth; and on this were placed closely-fitted polygonal blocks; where the blocks were defective, the interstices were filled-in with flints, and in some instances with wedges of granite, or metal; producing, on a horizontal plane, the appearance of a Pelasgian wall. The road was divided into three parts, the footway occupying the centre; this was raised above the carriage-way, and was somewhat broader: it was protected by upright stones placed at intervals, some being higher than others to assist the passengers to mount on horseback, the Romans using no stirrups. At the end of each mile was a stone inscribed with the number of miles from Rome, measured from the Columna Milliaris, in the Forum Romanorum. Every five or six miles, post houses were erected, each of which was to be provided with forty horses. Of such importance was facility of transit considered, that men of the highest rank were appointed to superintend the preservation of the public roads: Augustus himself was at one time surveyor of a district.

The Romans were probably the first builders of Aqueducts; for though the Etruscans excelled in tunnelling and draining, there is no record of any aqueduct (as the term is generally understood) before the time of the Roman republic. So necessary was it thought to have a plentiful supply of fresh water, that no expense was spared to obtain it. Water was conveyed from springs forty or even sixty miles distant; and in the most flourishing period of the Empire, forty streams flowed into Rome through fourteen aqueducts. Pliny says, speaking of the aqueducts, "If any one will diligently estimate the abundance of water supplied to the public baths, fountains, fish-ponds, artificial lakes for galley fights; to pleasure-gardens, and to almost every private house in Rome; and will then consider the difficulties that were to be surmounted, and the distance from which these streams are brought—he will confess that nothing so wonderful as these aqueducts is to be found in the whole world."

Some idea may be formed of the expenditure lavished upon an efficient water supply, from an application made by Herodes Atticus to the Emperor Hadrian, for 300 myriads of drachms for the purpose of bringing a stream of fresh water to the city of Troas in Asia Minor; at the same time reminding the Emperor that he had granted larger sums to much less important towns. Hadrian complied with the request; but when the aqueduct was finished, the expense was found to have exceeded 700 myriads; whereupon the munificent Herodes himself presented the extra sum to the city: 500 myriads amounted to about 161,458*l.*

These noble structures were erected wherever the Roman power extended. They were either single, with one row of arches, like the Aqua Martia at Rome; or in a double row, one over the other, like that at Segovia; or even triple, like the celebrated Pont du Gard near Nismes. This great aqueduct extends between two mountains, and crosses the river Gardon, which passes under the fifth arch; it is about 207 feet in height. The source of the Aqua Claudia at Rome, is 46 miles distant; the walls for ten miles were raised on arches, and some of which arches are 100 feet in height. The Romans gave a considerable inclination to the water-courses, and caused them to deviate from the straight line, in order to check the rapidity of the current. In some instances, the water was filtered through gravel laid for that purpose in the channel.

The Reservoirs, or Castelli, into which the aqueducts poured their waters, were of great capacity, and frequently elegant in design and decoration; one is described, built by Augustus, at Nicopolis, as a large oblong building, at each end of which was a reservoir fed by the aqueduct of the city; round the interior of the building were niches, where stood marble statues of naiads, holding shells, from which the crystal stream overflowed into the castellum. Thus did this luxurious people combine utility with beauty

In viewing the ruins of Rome, the observer cannot fail to be struck with the magnificent remains of the ancient Fora. These, like the Agora of the Greeks, were the great centres of business: they were open spaces, oblong in form, surrounded by porticoes and other public buildings, and adorned with altars, columns, and statues. They were of two kinds, the Fora Civilia, and the Fora Venalia; the former appropriated to the transaction of public business, the latter to the holding of markets. The surrounding porticoes were two stories in height, the lower serving as the offices of bankers and merchants, the upper for the populace assembled to witness the gladiatorial combats, which were exhibited in the forum before the erection of the amphitheatre. There were only two fora at Rome before the time of Augustus, who laid out a third; others were afterwards added by succeeding emperors. The principal, both in extent and importance, was the Forum Romanorum; which, amongst other public buildings, contained the Julian Basilica, the Curia Julia, where the senate held its sittings; and the temples of Castor and Pollux, and Jupiter Tonans. In this forum was the rostrum from which orators addressed the people: it received its name during the time of the Commonwealth, from being decorated with the prows of vessels taken from the enemy. The ruin of the great Forum Romanorum is so complete, that its very limits are a matter of discussion: its present name, Campo Vaccino, or bullock-field, describes its degraded state.

The Fora of Julius Cæsar, or Augustus, and of Trajan, were all celebrated for their architectural magnificence; the latter was entered by four triumphal arches, and in the centre stood the beautiful Trajan column, designed by the architect Apollodorus. This column, of the Tuscan order, is 12 ft. $2\frac{8}{11}$ in. lower diameter and 97 ft. 9 in. in height; the bas-reliefs with which the shaft is covered ascend in a spiral line from base to summit; within, stairs leading to the top are cut in the solid marble. It stands upon a lofty pedestal, ornamented with eagles, crowns, and other insignia: the ashes of the great Trajan are said to repose beneath. Part of a hill had to be cut away to afford room for the Forum Trajani, and the height of the column denotes the depth of the excavation. The Antonine column is nearly a copy of this; but as the shaft is nearly parallel, it is inferior to it in elegance.

The Curiæ and Basilicæ were always situated in or near the Forum; the former were places of assembly. Vitruvius recommends that in the Curia, the walls should be intersected by a cornice, to be continued round the interior, half its height from the floor; "for without this precaution, he says, "the voices of those who are debating, would ascend to the upper part of the court, and be lost to the audience. But when coronæ are introduced, and continued along the walls, the sounds will be interrupted in their ascent, and be distinctly heard before they are dispersed in the air."

The Basilica was a building adapted to the two-fold purpose of the meeting of merchants, and the administration of justice; it was of oblong form, divided by rows of columns into three, or five aisles; the longitudinal aisles were terminated by another in a transverse direction; here waited the advocates, notaries, and all those who were engaged in prosecuting causes. Opposite the central aisle, this division, or transept, projected out in a semicircular recess, raised a few steps, so as to form a kind of dais. This part was called in Greek *αβσις*, and in Latin *tribuna:* here sat the prætor with his assistants; and from this courts of justice have been called Tribunals. The longitudinal aisles were used by the merchants as an exchange; the central one was two columns in height, the upper row forming a kind of gallery. The aisles were covered by a flat ceiling; the tribuna with a semi-dome, or conch. The basilica presented a plain exterior, the decoration being within; the tribuna was the most highly ornamented part; it is uncertain whether the aisles were inclosed by walls, or whether only by arcades opening into the forum. There were also other apartments, called *chalcidica;* but for what purpose is unknown. Some suppose them to have been store-houses for the corn to be distributed to the populace; as, according to Varro, the *creta chalcidica* had the property of preserving grain: but this is mere conjecture—the term *chalcidica* is employed by some authors to signify all the rooms in the upper part of the house, generally used as store-rooms.

Leaving the buildings appropriated to business or utility, we now come to those set apart for entertainment and luxury; the most important and characteristic of which is the Amphitheatre, giving proof both of the wealth and power of the mighty Roman people, and of their ferocious and sanguinary disposition.

We have already traced the Amphitheatre to an Etruscan origin; the name first given to this kind of structure in Rome was Theatrum Venatorium, or theatre for hunting. During the Commonwealth, the gladiatorial games were generally exhibited in the forum, no permanent amphitheatre then existing. It is supposed that these games or combats were first celebrated at funeral feasts; but finding them so agreeable to the populace, those advanced to high offices in the state were accustomed to give them as bribes or rewards at their election, hence they were called donations. Gladiatorial shows soon became a passion with the people of Italy, and were encouraged as a means of exciting a fierce and warlike spirit; even Pliny the younger speaks of these games as proper to inspire fortitude, and to make men despise wounds and death. The first public show of wild beasts was on occasion of the victory obtained over the Carthaginians by Lucius Metellus, when the captured elephants were driven round the arena by slaves with blunted javelins, in order to dissipate the fear inspired by these strange and enormous animals. Wild beast fights do not appear to have been introduced till after the second Punic war. The amphitheatre was at this time only a temporary structure of wood, erected in the Campus Martius, and removed at the conclusion of the games. It is said that Caius Curio, tribune of the people in the time of Cæsar, gave an entertainment on his father's death, causing two theatres of wood to be constructed for the morning representations of the drama; these theatres were so contrived, that in the afternoon the semicircles were swung round, and made to meet at the extremities so as to form an amphitheatre for the exhibition of gladiators, with which the sports of the day terminated. The first permanent amphitheatre was built by Statilius Taurus, in the 725th year of Rome; this was a stone edifice, but of small size. As the degradation of the lower classes increased with the absolutism of the emperor, so the craving after these murderous games increased also; the populace of Rome were little better than a multitude of paupers, receiving their daily bread from the public stores, and *panum et circenses* became the popular cry. Perhaps it was found by their tyrants, that the exhibition of public games was an easy way of keeping the people quiet, by affording a safe vent to their love of excitement; but be this as it may, the old amphitheatre was found quite inadequate to contain the crowds that flocked to witness the shows, and in the reign of Vespasian, the great amphitheatre was founded, called the Flavian, from the name of the Emperor Flavius Augustus. It was completed by his son Titus, some authors say in three, others in ten years; many thousand slaves were employed in its construction. This enormous building is generally known as the Coliseum, either from its gigantic dimensions, or from a colossal statue of Nero that stood near. It is elliptical in form, 620 ft. in length, by 513 ft. in breadth, and is 157 ft. in height; it occupies six acres of ground, and was capable of accommodating 80,000 spectators.

The Roman amphitheatres and theatres are architecturally interesting, as affording the earliest examples of the use of orders one over the other on the exterior. The Coliseum has four stories, the three lower consisting of arcades, separated by piers and engaged columns; the upper, of an attic pierced with windows, the piers being decorated with pilasters. The lower order is Doric, the second Ionic, and the third Corinthian. Those who have examined the building disagree as to whether the upper order is Corinthian or Composite; Serlio, Taylor, and Cresy stating it to be Composite; and Palladio, Cipriani, Desgodetz, and others, Corinthian. As the wall of the building ascends, it gradually tapers inwards; the diminution in its thickness is given to the exterior, the interior face being vertical: this tendency to the pyramidal form greatly adds to its apparent solidity. In the two lower orders, the columns project more than half their diameter; in the third, exactly half. The Doric colums are upwards of nine diameters in height, and are raised on pedestals; the entablature is not quite one-fourth the height of the column; the frieze is plain, without triglyphs; the width of the piers is rather more than half the aperture of the arch, and the thickness nearly the same. The upper stories being so far removed from the eye, the capitals of the columns present mere indications of the order to which they belong. The lower arcade consisted of eighty portals or vomitories, numbered like the boxes of a theatre. The lower story was occupied by five corridors; from the second and third were the staircases giving access to the upper seats; from the fourth, a flight of marble steps led to the podium. There were four principal entrances, 16 ft. 4 in. in width; the other arches being only 14 ft. 6 in.; that to the north was the portal by which the emperor entered from his palace on the Esquiline. The interior central space was covered with sand, to absorb the blood of the victims; hence it was called the "arena." From this rose the podium, a wall 12 feet high and 14 feet broad, protected from the springs of the wild beasts by a small canal and a spiked railing; on the podium were the seats for the emperor, senators, foreign ambassadors, the vestal virgins, and the editor, or person who gave the games. The equites sat in fourteen rows above. The emperor's seat was raised, and was hung with silken draperies like a pavilion. Ranges of marble seats then rose one above another to the upper story, where wooden benches served to accommodate the lower ranks of spectators. Doors opened on to the arena below the podium, through which the gladiators and beasts entered; and the bodies of those butchered in the games were dragged out by a hook, into the spoliarium. Cells or chambers, have been discovered beneath the arena, which some have supposed to have been dens for the beasts; but it is uncertain whether the vivarium was contained within the walls of the amphitheatre: they were more probably used for the machinery necessary to the changes of scene produced on the arena. It was occasionally filled with water, for the representation of sea-fights; and sometimes trees were transplanted there, and artificial caves and rocks formed, amongst which the wild beasts lurked as in their natural state. During the work of slaughter, the audience were refreshed with jets of odoriferous water, rising into the air and dispersing like small rain; and were sheltered from the sun by an awning or velarium. Over the windows in the upper story are corbels, for the purpose of attaching the masts of the velarium, which passed through holes perforated in the cornice. The velarium was in six parts, drawn together by cords; it was generally of woollen cloth, but on particular occasions of embroidered silk. We are informed that the net-work before the podium was of gold wire, and the fasciæ of the benches ornamented with mosaic work of precious marbles; and that on high festivals the furniture of the amphitheatre was entirely composed of gold, silver, and amber. According to Martial, people flocked from all parts of the world to be present at the opening of the Flavian Amphitheatre; games were celebrated for 100 days, during which time 5000 wild beasts were slaughtered. In the reign of Trajan, an entertainment was given that lasted 123 days, 2000 gladiators successively appearing on the arena. Amongst the strange animals mentioned as taking part in the show, are ostriches, zebras, lions, leopards, elks, giraffes, elephants, and even the rare hippopotamus, who probably met with a less agreeable reception than amongst the novelty-hunting fashionables of our metropolis.

The games of the Amphitheatre was the last remnant of Paganism that gave way before the dawning light of Christianity: they were not abolished till the fifth century. Gladiatorial combats were put an end to by the courage of the monk Telemachus, who rushed upon the arena, and endeavoured to separate the combatants; he was instantly torn to pieces by the brutal populace, but the heroic deed roused the Emperor Honorius to exert his authority in repressing a spectacle so obnoxious to the religion he professed. These shows ceased from that time, but fights with wild beasts continued to be exhibited till the reign of Theodoric (523 A.D.) Since then, the Coliseum has fallen into disuse, and was long a prey to the spoiler, till it was consecrated by Pope Benedict XIV., who erected the cross that now stands in the centre. There is a prophecy relating to this building recorded by Venerable Bede: "As long as the Coliseum stands, Rome shall stand; when the Coliseum falls, Rome will fall; when Rome falls, the world will fall."

There are remains of four other amphitheatres—those of Verona, Capua, Nismes, and Pola in Istria; these are all similar in plan to the Coliseum, though of smaller dimensions. That at Verona is of rustic work; the piers between the arcades are decorated with pilasters. The amphitheatre at Nismes has two stories of the Doric order. That at Pola differs from the others in being situated on the slope of a hill, so that nearly one-half of the ellipse is on a more elevated plane than the rest; the basement and first story on that side are suppressed, and most of the seats are supported by the natural slope of the mountain. This building consists of three stories above the basement, which is of rustic work, strengthened by buttresses and surmounted by a cornice; in this part are several square doorways. The first story has Doric pilasters, without bases, but resting on pedestals, and with a rustic entablature; the second story is similar, but the piers are slighter, and the pillars rest on a continuous stylobate, or surbase; the third story is an attic, perforated by square windows, one over each arcade. The curve of the amphitheatre is interrupted by four projections, each of the width of two arcades, containing staircases.

Besides the amphitheatres, the Romans had Naumachia, in which the central area was filled with water for naval combats; and Circi for horse and chariot races. The Naumachia of the Emperor Augustus was 1800 feet long by 1200 feet broad. The Circus was of the same form as the Hippodrome of the Greeks; but the seats, instead of being laid out on the natural elevation of the ground, were raised on arches like those of the amphitheatres. There were several circi in Rome; the principal was that known as the Circus Maximus, founded by Tarquinius Priscus. It was much enlarged and improved by different emperors, and offered accommodation for no less than 485,000 spectators. The two Egyptian obelisks now seen in Rome, formerly stood upon the spina of this circus.

The Theatres of the Romans so closely resembled those of the Greeks, that a detailed description is unnecessary; the greatest differences were, that all the performances took place on the stage, the orchestra being the place where the senators, and other persons of distinction sat; and that they were built on level ground, the exterior presenting several stories of arcades, like the buildings already described. The first permanent theatre in Rome was erected by Pompey the Great. The Theatre of Marcellus was built by Augustus, in memory of the son of his sister Octavia; this was of two orders, Doric and Ionic, and was sufficiently large to contain 30,000 spectators. At one time there were as many as three thousand singers, and three thousand female dancers, engaged in the theatres of Rome; and during a severe famine, when all strangers, including artists and professors, were banished from Rome, these alone were exempted—so necessary had the amusement they afforded become to the luxurious and pleasure-loving Romans.

The great Thermæ, or public baths, also strikingly displayed the prodigality and magnificence of this people; indeed, some of the descriptions of these places more resemble the inventions of romance; than sober matter of fact. The vast halls were supported by elaborately wrought columns of foreign marbles, and decorated with the finest works of the sculptor; the walls enriched with fresco painting and gilding, and the pavements composed of beautiful mosaic work; candelabra of bronze or gold, of exquisite workmanship, shed from their lamps a softened light through crystal globes; and the rarest perfumes floated on the air. Besides bathing-rooms, these buildings contained libraries, gymnasiæ, exhedræ for conversation, and, in short, everything was assembled under one roof that could contribute to the health of the body or the recreation of the mind. In the time of the Commonwealth, the public baths were extremely simple, consisting of a few obscure chambers, with small openings in the wall instead of windows, the belief prevailing that darkness helped to retain the heat. It is said that the refined descendants of an Etruscan King—Mæcenas—first introduced the thermæ in their improved state into Rome; in aftertimes there were no less than eight hundred public baths in the imperial city alone. The thermæ contained seven principal descriptions of rooms for the convenience of the bathers—the Apodyterium, a sort of dressing-room, furnished with tables and shelves where the bather might deposit his clothes, which apartment was also called the Spoliatorium; secondly, the Unctuarium, a smallchamber where oils and perfumes for anointing the body were kept; thirdly, the Sphæristerium, where exercise was taken to open the pores of the skin before entering the bath, and where a kind of game was played something resembling tennis; then followed the Frigidarium, or cold-bath, which room was generally exposed to the north, and contained various vessels for washing; next, the Tepidarium, placed between the cold and hot bath; and beyond, the Caldarium, which was the most frequented, and was situated immediately above the hypocaustum or furnace. The bath was constructed of brick or masonry, lined with cement, and having a margin of stone; the bottom inclined so that the greatest depth was in the centre; it had a flight of steps leading down into it, and was surrounded on three sides by a balustrade, to divide the bathers from those who were waiting their turn; the windows were placed high, so as to prevent the apartment from being overlooked from without; some of the halls were without windows; and were lighted by candelabra both by night and day. The last room contained the Piscina, or swimming-bath, which was, in some of the thermæ, of such an extent as to be a complete lake of warm water; this constantly flowed in through a brazen pipe, the convolutions of which passed through the furnace. The piscina was sometimes elevated, so that the prospect might be enjoyed while swimming about; it was then called Balinea pensile. Another kind of bath was generally contained within the building, for the use of invalids; this was the Laconicum (so called from its having been used in Laconia), or Concamerata sudatio; it was close to the furnace, and was a small chamber with a domical roof, in the aperture of which was a brazen shield, which was raised or lowered to regulate the temperature; round the chamber were niches called Sudationes, where the bathers placed themselves: this kind of dry bath was much used by aged people. There is much uncertainty as to the mode of heating the quantity of water required in these great thermæ; but the water appears to have flowed from the castella, or reservoir supplied by the aqueduct, into vaulted brick chambers, over the furnace. As the water was drawn off in a boiling state from the last chamber, it was replenished from the next, only a few degrees less heated, so that the heat was never checked by the admission of cold water. The wealthy had private bathing apartments in the great thermæ, where the baths were made of copper or porphyry; many such have been found.

The most celebrated thermæ in Rome were those of Titus, Caracalla, and Dioclesian. The Baths of Titus are supposed to occupy the site of the more ancient building of Mæcenas; here were discovered those beautiful frescoes from which Raffaelle himself did not disdain to copy. In order to preserve these paintings from being injured by the splashing of the water, the walls for ten feet of their height are incrusted with coloured marbles. The Baths of Caracalla contained fifty halls and sixteen thousand marble seats; four grand staircases led to the upper story, where the apartments for exercise and conversation were situated: 288,000 cubic feet, or 1,800,000 gallons of hot water were distributed through these baths every hour. In one of the great halls of the Baths of Dioclesian is the only existing example of the use of the Corinthian and Composite orders in the same apartment: there are four Corinthian columns at the angles of the hall, and four Composite supporting the vault in the centre; the shafts are of granite, the capitals and bases of white marble. From the ruins of the different thermæ have been dug some of the most valuable works of art; amongst the rest the Laocoon and the Farnese Hercules.

Triumphal Arches are undoubtedly of Roman origin, no records existing of any such structures before the time of the Commonwealth. It was an old custom in Rome, to honour the victorious generals with a Triumph on their return from foreign conquests: on these occasions temporary arches of wood, decorated with festoons of laurel and flowers, and trophies of war, were erected over the Via Sacra, the road they passed along on their way to the Capitol. On the arch were stationed musicians, and a figure of Victory so contrived as to drop a wreath on the head of the conqueror as he passed beneath: this is the origin of the figures of Victory holding out a wreath, sculptured on the spandrils of the arches. Those who had been honoured with a triumph, were naturally anxious to perpetuate the memory of such an event; and to this end caused the temporary wooden arch to be replaced by one of stone.

The triumphal arches erected during the Commonwealth were (judging by the representations on ancient coins) simple and unadorned, save by a commemorative inscription; but under the Empire, they, like every other kind of building, were elaborated to the utmost that wealth and a sumptuous taste could devise: and as the decorations and inscriptions recorded the events that led to their erection, they are not only admirable for their beauty, but valuable as histories carved in stone. The earliest in date now remaining is the Arch of Titus, erected by the Emperor Domitian to record the victories of Titus over the Jews. This structure consists of one archway, with an attic supported by four engaged Composite columns on each front. The columns at the angles are returned on the flank, where they have a greater projection than on the front—they project nearly half their diameter; the two columns on each side the arch stand on a continuous pedestal. The opening of the archway is an exact square to the springing of the archivolt; the entablature is one-fourth the height of the column, and the attic nearly half the height of the order. The whole is constructed of large blocks of Parian marble; one of the stones of the cornice is 10 feet in length; the architrave and frieze are in one block in height; the arch is composed of eleven voussoirs; the blocks were originally fastened by metal cramps, most of which have been removed. The archway is adorned with bas-reliefs, representing the conquests of Titus in the East; one of these is particularly interesting, the subject being the sacred utensils, candelabra, &c., belonging to the Temple at Jerusalem, borne in procession at the Triumph of Titus.

The arches of Septimus Severus and Constantine, consist of three openings, the central one being the largest; they present a similar façade on each front, having four detached columns, backed by pilasters resting on the same pedestals as the columns.

In the Arch of Septimus Severus, the arches communicate with each other by cross openings. The detached columns have been objected to, as having nothing to support, and therefore being useless; the two inner ones are not even surmounted by pilasters on the attic. The statues placed on the entablature remove this objection in the Arch of Constantine. The Arch of Septimus Severus is of the Composite order, and is 76 ft. 4$\frac{1}{2}$ in. in height, by 68 ft. 2$\frac{1}{10}$ in. in breadth; the columns are ten diameters in height. The openings are lofty; the centre one being nearly, and the side ones quite, double their width up to the springing of the arch. It is richly decorated with bas-reliefs, and had formerly a triumphal car on the summit, with statues of the emperor and his two sons.

The Arch of Constantine is made up of parts carried away from other structures, which the architect has not even known how to apply properly. No artist was found in Rome capable of executing the bas-reliefs;. they were therefore most inappropriately borrowed from the Arch of Trajan, the subjects setting forth the conquests of the latter emperor, instead of those of Constantine. The structure altogether presents a curious mixture of two different periods, and of the best and worst taste. Amongst other incongruities it may be remarked, that the cornice of the impost has both dentel band and modillions, while that of the entablature has modillions without the denticulus.

Besides the Triumphal Arches, properly so called, there are many, either simply commemorative of some person or event, or serving as ornamental gates to a city: such are the arches of Gallien at Rome, of Hadrian at Athens, and of Trajan at Ancona. Speaking of the Arch at Trajan, Serlio says, "those who understand art, are not only delighted with the admirable intelligence shown in its construction, but render thanks to the architect for having produced a work by which our age may be instructed, and may discover the rules of the beautiful." This arch is small, being only 9 ft. 10$\frac{8}{10}$ in. in width, but lofty; it is more than twice its width to the springing of the arch. On each front are four Corinthian columns; it is erected on a basement; a bust of the emperor is sculptured on the keystone; and the spandrils and walls between the columns were formerly decorated with bronze ornaments. It was built 116 A.D.

We have now passed in review the principal public buildings of the Romans; and in the next Lecture, I propose to inquire into the Domestic Architecture of this great people, though comparatively little is known on this subject, owing to the few remains.

LIST OF AUTHORITIES.

Vitruvius—Decline and fall of the Roman Empire; Gibbon—Architectural Antiquities of Rome; Taylor and Cresy—Les edifices antiques de Rome; Desgodetz—Architettura; Palladio—Architettura; Serlio—Encyclopedie Methodique—Ancient and Modern Architecture; Gailhabaud—Fabbriche antiche di Roma; Cipriani—Verona Illustrata; Maffei—Antiquités de Nismes; Clerisseau—Baths of Titus; Ponce.

DEVONPORT MECHANICS' INSTITUTE.

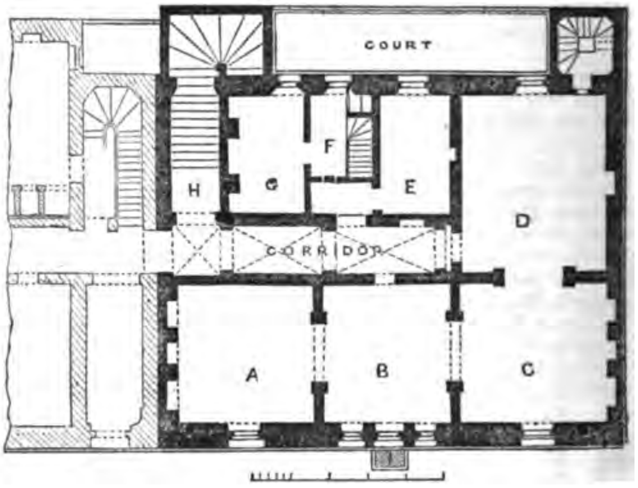
The great town of Plymouth, Devonport, and Stonehouse, is well supplied by the liberality of its inhabitants with libraries and institutions. We lately described an institution at Plymouth, and we now bring before our readers the design for the extension of the Devonport Mechanics' Institute, carried out under the direction of Mr. Alfred Norman, architect, practising in the town.

The engraving shows the front towards Duke-street, which, on the ground-floor, is surmounted by an entablature of the Doric order, and is constructed of Portland stone. Above this ground-floor are two rows of windows, the lower being smaller, and a kind of base to the upper row. They are designed to give light to the lecture-hall and galleries. The elevation, it will be seen, is terminated by a cornice, with projecting brackets and eaves roof. There are three windows in the width, and the middle one on each floor has three openings. On the ground-floor this centre window has its openings formed by two Doric columns, the shafts of which are rusticated, in correspondence with the quoins forming the dressings of the side openings, and of the two other windows. The cornices and consoles of the lower part of the middle range of windows support the balconies and balustrades of the upper range. In the upper range, the middle window is converted into an arched Venetian window, with the central opening of which the window-head on either side corresponds, having a richly-moulded arch-head and ornamented keystone. The dressings are of Portland stone, and the rest of the work of limestone rubble, faced with Portland cement.

The interior contains upon the ground-floor a library, 60 feet in length by 15 feet in height, and which may be converted into three rooms, connected by two large open arches. The end or side divisions only are for books, the middle one being used as a museum. On the ground-floor are likewise a class-room and some officers' rooms. The upper floor is occupied by the great lecture-hall, 61 feet by 46 feet, and 30 feet high, lighted by a double range of windows. In the hall are likewise galleries. The ceiling is divided into compartments by carved beams, and the walling is finished with an enriched frieze, cornice, and cove. One large central ventilator, and two smaller ventilators, are made ornamental. The building was finished in the spring of this year, and the whole cost was about 2500*l*.

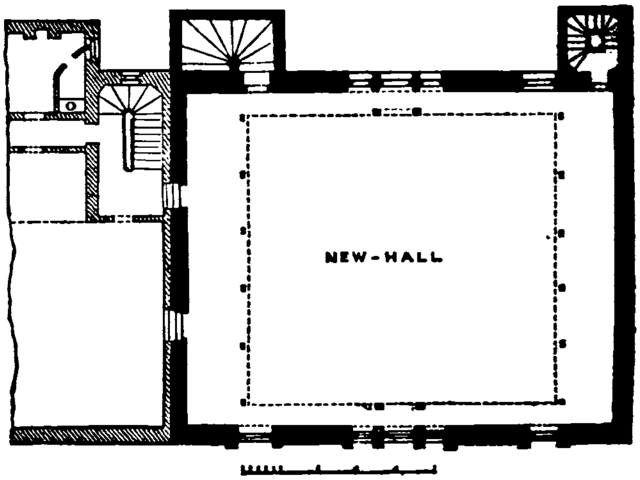
Ground Plan.

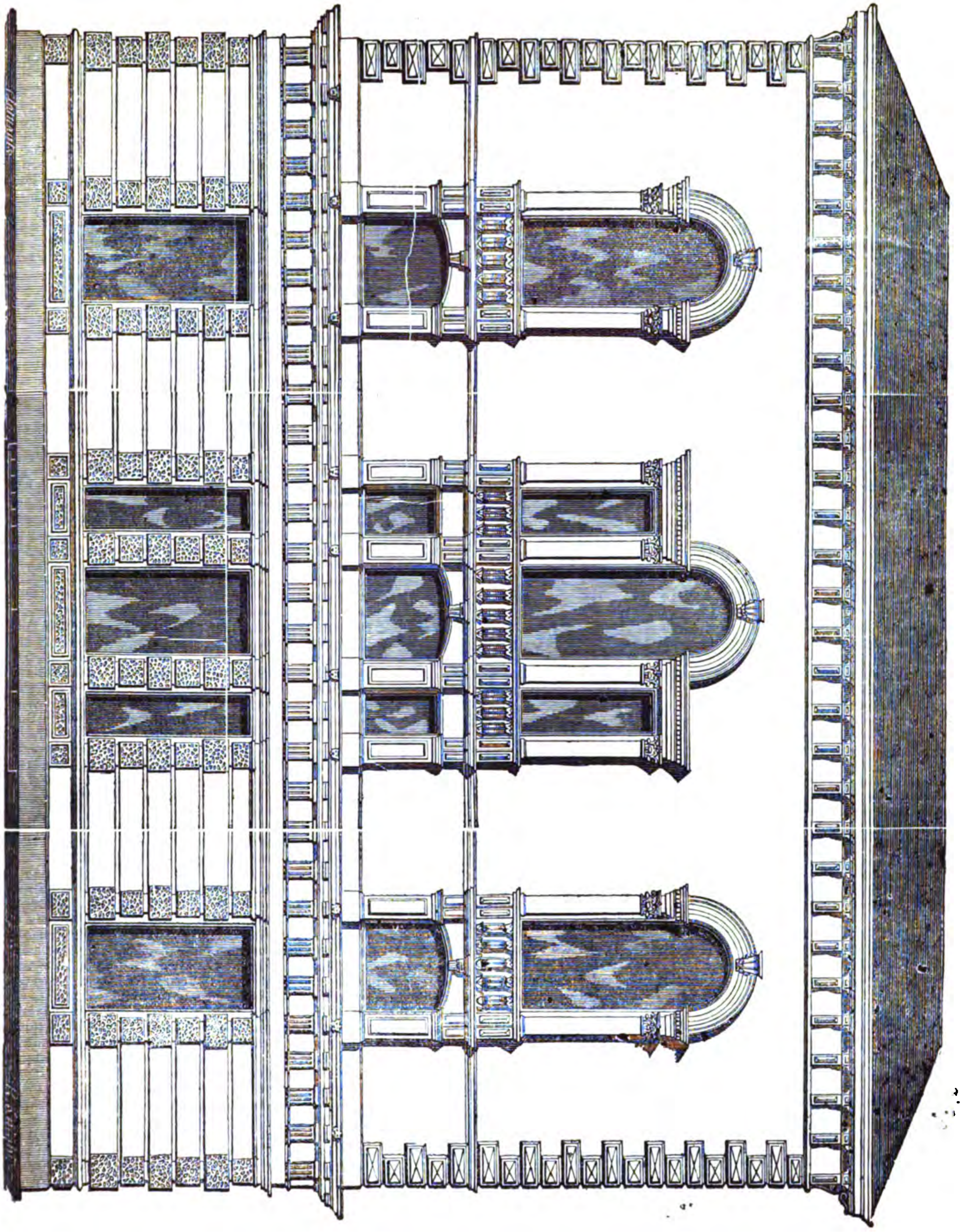
A, Library; B, Museum; C, Library; D, Class Room; E. Parlour; F, Staircase. and Scullery under; G, Kitchen; H, Staircase leading up to the New Hall.



Upper Plan,

Contains the New Hall, with a Gallery above. The situation for the Lecturer is at the Window between the two Staircases, and that for the President opposite. The part not tinted is the old building.





DEVONPORT MECHANICS' INSTITUTE.—MR. ALFRED NORMAN, Architect.

ROMANESQUE ARCHITECTURE.

A few Remarks on some of the leading points of Romanesque Architecture. By James Edmeston, jun. (Paper read at the general meeting of the Architectural Association, Lyon's-inn Hall, 18th October, 1850.

It has not been by any means the chief aim in the subsequent remarks, to enter into an historical or antiquarian account of the rise and development of those architectural forms exhibited in the early ecclesiastical architecture of Italy, and which usually pass under the name of Romanesque, any further than is necessary for the sake of distinction and elucidation. It is, on the contrary, I believe, often desirable to escape as much as may be from all influences which are not to be found in the art itself; to think upon, and to view it for instruction and guidance, as architectural students; believing that such inquiries as we have alluded to, too minutely followed out, are more proper to the antiquarian than the architect, and that they too often, to the great loss of the student, carry away the imagination, and blind the vision to those real and lively principles of the art which ought first to claim his attention. It is, nevertheless, necessary to trace the development of succeeding forms and arrangements—their origin and progress; because, in tracing the growth of the first rude attempts to the latest perfection, the architect learns to understand the inferior stages of development, and wins his way to the better starting point for his own exertions, sees that progress and onward movement is the very soul and life of his art, and receives by the study a mental discipline and correction that trains his own mind for vigorous exertion, and helps him to throw aside fearlessly the trammels of conventionalism and fashion.

It has always seemed to me that the study of those architectural efforts called Romanesque is, to all these ends, useful and well fitted; it is simple and vigorous, determinate and striking; bold in its effects; with all its simplicity, very often artist like; often mistaken, yet the production of no paltry and flimsy tone of mind, but the solid expression of real wants, deeply felt and fervently put forth.

It is again an especially interesting study if it is allowed—as to me it appears that it should be—that it shares with the Byzantine the parentage of all the later styles, Christian and Mahommedan: and without staying for one moment to inquire into the vexed question as to whence the Pointed arch arose to work its mission of revolution in the architectural world, I will claim this fact for the Romanesque, that it was through it that society, under its much changed and altered conditions, shook off those chains that bound the art to Classic models; and that it adds one more bold unanswerable witness of the fact, that *progress* is the life-blood of architecture; for that age—glowing freshly with the first benign influences of Christianity, and daring to throw aside the beautiful forms presented by the Pagan world—thinking and acting for itself, led the way to those delightful creations of the later Gothic school; and has thus earned the respect of all subsequent ages, and deserves well of all lovers of architecture; well merits the student's careful attention, and cannot fail to reward him plentifully for the industry he may bestow.

Lest any one should think, by the passing allusion above to the pointed arch, that I suppose it invented by Romanesque architects, I will simply record my belief that, like the circular arch, it was known, and occasionally by chance was used, much earlier; that the Arabian architects used it first as a general feature, but that for the Gothic architects was left the enviable task of evolving the true principles which it contained—of working it out and bringing it to its highest perfection.

In passing, I cannot help observing the great advantages which architects of these later times have over their fathers; the architectural expressions and knowledge of cycle on cycle of the world's efforts in the art, is laid before them for their instruction by innumerable careful and talented works on the several subjects; and the architect, in a few years, and in his own studio, may learn more than he could formerly have learnt in as many lifetimes. Oh! surely these advantages should never be abused to the stultifying and annihilating of his own intellect and genius; but ought, on the other hand, to be so many powerful incentives to his fresh exertions—nourishment to strengthen his imagination for renewed efforts—beacons to show him the rocks to be avoided in his course —pinnacles of ambition which he may reach, and from which he may see a yet unattained world of beauty beyond.

By Romanesque, then, I understand that style of architecture which was used after the decline of Roman power, and the removal of the seat of government to Byzantium; and which continued until the use (I will not say the discovery, but until the use) of the pointed arch led the way to the entire change in Christian architecture—till what we call Gothic became prevalent in Italy, and long after it was generally used in other countries; extending, as to time, therefore, from the middle of the fourth even to the thirteenth century, for Pointed architecture obtained no certain footing in Italy till after that time. The locality in which this style prevailed was confined to Italy—that is, North Italy and Lombardy, and is very distinct from that architecture very properly called Byzantine, which was the work of Greek architects, of a much more oriental character, and with many distinctive marks; having, in fact, Greek architecture for its basis, as Romanesque had Roman on the one side, and the early German Gothic—which, in many respects, appears akin, but is nevertheless very different—on the other. The distinctions between the churches in this style are chiefly between those built at and near Rome—which was for ages a great quarry, from which were taken not merely stones, but parts of buildings, columns, cornices, &c., to be worked up whole into other buildings (and they therefore partook more of the old classic models)—and those Lombard edifices, and others, at a distance from such assistance, and which are therefore more defined in style, and give clearer evidence of a step or two towards the Gothic.

First, then, let us consider the *plans* of buildings in this style: the earlier ones are found in the great majority—perhaps in all cases where Pagan architecture was employed—to be exactly that of the ancient Basilica, or hall of justice; that is, a parallelogram, or nearly a double square, with the semicircular or octagonal recess at one end, usually called the apsis—in the court-house, the judge's seat; but in the church, the sacred place where the altar was placed, and round which sat the bishops and presbyters. In some examples the atrium adjoining was retained, as at San Clemente near Rome, and San Ambrogio at Milan; and which, in appearance at all events, would appear to bear some analogy to the more modern cloisters. In some of the later edifices we observe the transeptal arms broken out, as in a Gothic cathedral; but by far the most usual is the simple Latin plan—though we do, in some instances, see some examples of the Greek cross; but these must, in all cases, be put down as the work of Greek architects, for the Latin architects never altered the more ancient form to which they were accustomed. And I think, beyond all question, this simple plan, so much preferred by the early Christian church, may be traced through the Romanesque to the Gothic; and that there can be no doubt but that it was the excellent basis which lies at the root of all the variations which that style engrafted upon it. This form of plan was used by the early Christians, doubtless, because in many cases they found it ready presented before them in the already existing basilicas, which they easily converted into churches; and secondly, because its simplicity was admirably adapted to their wants—the central nave and two side aisles: the northern assigned to the women, the southern to the men; the centre occupied by the choir and sub-deacons, then by the neophytes and candidates for baptism; and lastly, near the door, by the penitents.

True, we find this simple plan extended and added to subsequently, though always preserved as the main principle of arrangement, particularly in the neighbourhood of Rome; and those alterations which did take place, as the addition of transepts, &c., are much the most usual in Lombardy. The single apsis was never forgotten; but others were added at the end of the aisles, then to the transepts; and as the fashion of building chapels to tutelary saints became more in vogue, they were even broken out laterally. In all the earlier instances the floor was level, except only two or three steps to the apsis, where the high altar was situated; but as the prejudice against burial within the consecrated walls died away, and as the Church began to build for itself, we find the introduction of a new feature in the plan, and which is treated with the utmost importance—the crypt, which in these edifices appears not as a place of sepulture, but as a sort of lower church, complete with its altars and shrines; supposed by some to have been erected in imitation of the catacombs—those early places of meeting, in which the early Christians were wont to hide themselves, and to carry on their simple but sincere worship. Whether this be a mere fanciful supposition or not, what we know is, that they were prepared for the reception of the bodies of confessors and martyrs; and as such were treated with as much care and attention as the rest of the church—not sunk into the earth, but often nearly on a level with the floor of the nave, and with a number of steps ascending to the choir above (which had then been removed from its first position in the nave), just as we see it at Canterbury: it is thus at San Miniato at Florence, and at San Flaviano near Montefiascone, where there is a complete lower as well as upper church; at San Francesco at Assisi, where the great St. Francis was entombed; at San Zenone at Verona, and many other places.

This custom of building crypts and subterranean chapels was continued in the architecture of our own country until the last half of the eleventh century, but probably not much later.*

Considering these churches in section, we find in the earliest examples, arches springing from the capitals of the columns between the nave and aisles, and carrying a clerestory; the roofs in all cases of low pitch, of wood, with level tie-beams; the trusses near together, and the aisle-roof generally of less pitch than that over the nave, just as we usually see it in our own parish churches. The flank walls at first flat, till in the church of Santa Maria at Toscanella, erected in the seventh century, we find them relieved by piers and arches projecting from the face, and as if forming recesses in the wall ready for ribs and cross springers, but with the groins left unexecuted. In the church of St. Agnes near Rome, built a little later, we have another step in advance, for the clerestory is raised higher, the aisles are groined, and over them are galleries, with a second series of columns and arches over the nave columns, with a balustrade between, forming excellent and spacious galleries; being an arrangement in this style precisely similar to that of our own cathedrals with their triforia. The aisles, although groined under the galleries, are, with the rest of the church, roofed above with wood, which again reminds us of a practice usually followed by the Gothic architects. These galleries, most probably, were for the use of the women, as the triforia have been conjectured to have been used by the nuns. In the Cathedral of Pisa, built in the latter part of the eleventh and beginning of the twelfth century, we find this arrangement magnificently treated, and with a still nearer approach to the Gothic treatment, for the piers are carried through and within the larger arches; springing from one pier to the other, are again two smaller arches, with a column in the centre. The proportions of this cathedral are noble and lofty, the galleries spacious and most effective features. The aisles are double, divided with a range of columns down the centre; they are groined, but the roof is of wood, as in the former examples: and here we find very successfully introduced the alternate courses of red and white marble, a fashion just then obtaining—here confined to a cross in the spandril between the nave arches, and to the striping of the clerestory and projecting ribs of the groining. The good taste of this practice is much questioned; but it has certainly here received the sanction of a masterly mind, for such must have been the architect of this cathedral. It seems to me, that care bestowed in arranging the different materials in a building as to colour, is admissable, and capable of adding much to the good effect—though much overdone in some of these examples.

It can hardly be well used over the whole of a large building—it is much better confined to parts which can be easily taken into view at once, and is, I think, particularly applicable to circular work of any kind. There is a great defect to be remarked in the groining of the aisles in this cathedral, inasmuch as the springing is considerably above the cap of the central columns, so that there is first of all a sort of pier above the cap, which gives an appearance of great weakness; but even at this later period, we find the earliest model was not entirely deserted, for at San Zenone in Verona, built in the twelfth century, there is no triforium or gallery; but a magnificent effect is got by the well-proportioned simplicity of the design, and by the alternate piers and columns between the nave and aisles. In this church, alternate layers of marble and brick are used.

In the Cathedral of San Francesco at Assisi, erected in the thirteenth century, built by a German architect, we find the first example of any importance of the introduction of the pointed arch in Italy, From this time it became always used, with more or less mixture of the now declining Romanesque; the effect of which is particularly evident in the fine Cathedral of Sienna; in which we have the pointed arch with the mixture of Classic details, cornices, consoles, capitals, &c., the walls being composed of layers of white and black marble.

The whole of the interiors of these churches were lavishly decorated with fresco, mosaics, &c. A great difference is, however, observable between the style of decoration which was followed in the Lombard churches of Northern Italy, and those nearer Rome. The former are remarkable for great stiffness of design, very gross imagery, grotesque carvings and ornaments, all crowded and huddled together, the foliages bearing some analogy to our own early Norman, and by no means equal to the Byzantine of the same date. The latter are much better in arrangement and drawing; their excellence, however, is only comparative.

In the earlier Romanesque churches, the exterior effect would seem to have been deemed of an importance altogether secondary to that of the interior, presenting often little else than bare walls, with few and ill-arranged openings. After a while, however, we find these made more important, and the exterior walling broken into piers and recesses, particularly the apsides, which were decorated with long narrow three-quarter columns running up to the eaves. But a much more decided attempt to gain an effect is made by the introduction of arcades or passage-ways in the thickness of the wall, particularly round the apsides, immediately beneath the eaves, as if for a passage-way from one gallery to another, without the necessity of entering the body of the church. This is the case with two of the churches at Pavia, San Frediano at Lucca, a church at Arezzo, &c. The Cathedral of Pisa has an arcaded facciata of no less than four tiers, as also has San Michele at Lucca, and Santa Maria at Arezzo. These arcades might, perhaps, have been used as a sort of cloisters, though hardly very much retired; and, from their elevated and commanding situation, much more calculated to enliven and delight him who walked therein, than to lead his mind to those quiet and abstract contemplations which would be more congenial and suitable.

If not for some practical purpose of this kind, I am unable to determine what may have been the use of this oft-repeated feature; where sparingly used in the towers and apsides it is very effective, but in some of the examples above cited, it would appear to be overdone—to be made too distinctive, so that the outer wall is made nothing less than a screen to an inner one; whereas, if treated as part of the external wall, the relief thereby given to it, and the solid effect, the depths of shade, and points of bright light, conspire together to assist the effect of the whole very advantageously.

In the façade of San Pietro at Spoleto, we have an instance of a style which has been very aptly called the "*Cabinet Style*," a style which I think has never wholly become obsolete, but is occasionally followed even in this day. It may be called the climax of un-architectural effect. Bad proportions, bad arrangements, and bad construction, are all, of course, un-architectural; but still a building, with all these faults, may have more of the architect about it than a building in the style now alluded to. It may have what this style really wants—some leading idea and purpose, some fine and poetic notion, even let the result fall never so far short of the achievement it proposed to reach. Here we find a nearly equal surface for the façade, with certain square lines ruled upon it across each other, so as to form the most prim and severe-looking panels; in them are set certain circular windows, doors where needed, and surrounded by a profusion of laboured ornament and decoration; each part utterly discordant with the rest, and the whole very ingenious, but telling most significantly of efforts painfully abortive, as far as regarded anything good in the ultimate effect, being after a manner which would be much more suitable to the inlaying of a work-table, or any other similar piece of furniture, than for a work of art of a nature so much more exalted as Architecture. And the architect who neglects truthfulness, who seeks to hide construction, who fears too much to show the anatomy, so to speak, of his design, is in great danger of falling into such a style as this.

What, then, beyond the mere appreciation of detail and general arrangement—or *vice versa*, the lessons to be learnt from bad detail and arrangement—is the profit to be gained from the careful study of the architecture of that period and country now under consideration? The study of detail is useful; but far more important is it that the student should seek for principles—the principles which lie at the root of all the details and forms which outwardly appear as the results of those principles; growing upon them, and the whole succeeding or failing, as the first basis is justly founded or not.

Now, in this style we observe the transition from the Classic to the architecture known as Gothic—that is, from a mode of treatment the whole life and soul of which is contained in the successful application of lengthened horizontal lines, and of figures bounded by such parallel lines, to another mode of treatment whose very essence is contained in the like use of lengthened vertical lines, and of figures bounded by such lines. This being a style of transition—for the Classical treatment was wholly unsettled by the use to which the circular arch was put in this style, and as

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* In the discussion which followed, St. Leonard's, York, a church at Madley, Herefordshire, and Hereford Cathedral, were mentioned as having crypts of a later date.

yet the great principles contained in the pointed arch lay dormant, — we find a mixture of the two principles; and to this we may attribute that unsuccessful and unsatisfactory effect which, notwithstanding the good points we have been able to allude to, generally marks the style: and it is well worth the trouble of a patient study, if we may demonstrate from these examples that any conjunction of these two principles, so perfect in themselves when kept apart, cannot succeed—that they will not assimilate.

In these times, when, happily, there is a desire and purpose abroad to escape from copyism, and attempts at positive re-production, it is of the utmost importance to determine what may and what may not be attempted with a fair chance of success; and in the study of earlier styles to this end lies the great advantage—of consequence infinitely greater than the minute differences in the contour of a set of mouldings or the style of foliage, decoration, or indeed anything else subordinate to the great radical principles which must lie at the bottom of the superstructure of ideas, even though, perhaps in great part unsuspected by those who set up the edifice of mind and taste.

In all the earlier history of Architecture, in all countries and in all ages, we find that it is the natural offspring of the social condition, circumstances, and bias of each nation, and the strong expression of those feelings and tendencies which had most weight and were the most prominent features in the national character. Nothing, indeed, could be more natural than that it should be so; for whether a nation would express the glowing fervour of religious enthusiasm, or the towering pride of warlike ambition; whether the voluptuous luxury of careless ease and inaction or the chaste and pure breathings of a lofty philosophy and elevated poetry—to what can it fly more suitable to express and show clearly to the world such marks and features? to what, in the range of art, so capable as Architecture to bear such impressions, and to proclaim them intelligibly to all beholders? Thus was it in Egypt and Greece. Had the social state of the Greeks been less highly polished and refined, their intellectual culture less, and their religious feeling more, should we have had their architecture? Had the fervid and enthusiastic, yet seclusive and predestinating, religion of Mahomet found no followers, should we have had the quaint but poetical Moresque? Or, turning to the delightful and refreshing picture of mediæval art, from whence should we derive its peculiar and individual expression but from the pure and holy standard of the Christian religion? the whole overflowing with a loftiness and aspiration of idea which was never previously seen—was never called into existence—simply, because then, for the first time, had those particular stimulating necessities arisen; the fountain of thought then bubbled up from another region, flowed down from a different source, and nourished a different landscape into beauty and loveliness.

The characteristics of this age in our own country, in a secular point of view, are the luxuriousness and magnificence produced by the influx and accumulation of increasing wealth in individuals and noble houses; a rapid spread of invention and scientific discovery; great and increasing national power and resources; a peaceful industry and love of peaceful arts, but an energetic resistance of all aggression; a great pride of country and love of home; and desire for national pre-eminence, to be gained rather by solid institutions and sound government than by force of arms or political intrigue and chicanery. If Architecture, then, had been allowed to have the guidance of its own natural laws of progression, it might be perhaps supposed, with some show of reason, that a national style would have grown into strength and beauty; which, preserving the treatment peculiar to the mediæval styles, would yet have been influenced by the refinement of the Greek, tinctured to some extent with the ornamental profusion of the Roman: a style bold and massive, resting for its effects upon solid proportions rather than upon detail—most likely with a leaning towards the pier and arch treatment rather than to the columnar; different from all that had come before, and as English as our ships, our laws, or ourselves.

Yet, should such a thing ever come to pass by the lesson before us, we see that it never could be done by any incongruous mixture of old examples and styles. What we must look for to realise any great change is some new principle—some great main idea; and should such be discovered, then, without difficulty or effort, we should have a new and national style. Till then we may rest assured that the great principles already known to us admit of many applications different from those that have already appeared, and which will doubtless reward a patient investigation. And we shall do well to abstain, not merely from copying, but from gaining originality by any clashing mixture of old styles: the result may very possibly be quaint, perhaps with some merit; but could never become a style, and never be beautiful, because always imperfect.

I think we may also receive some instruction relative to that which is an important consideration in modern church architecture—namely, how to introduce galleries.

It is very generally conceded that in our crowded cities, it is impossible to keep galleries out of our churches; and, indeed, I know not why it should be thought desirable to do so, for in a Protestant church, where hearing quite as much as seeing is the requisite, it is a ready means of bringing a great additional number within the required distance. I believe, if treated as a mere piece of cumbrous furniture, a mere stage put up without connection or any harmony with the rest of the building, that it must always be wholly unsuccessful and unarchitectural. If, however, treated as in some of these churches (St. Agnes, for example), there is no such objection—no such fault to find. In a Gothic church, put—as we usually see it—where it ought not to be, it is obtrusive and unpleasant. In a church of Classic design—as we usually see it—it has the appearance of an inharmonious erection in a disproportioned room. But only let it be above the arches between the aisles and nave; only let the lines of the nave be continued up to the roof, the gallery not interfering with it—and the whole is compact and proportionate The beauty of the Basilica plan, whether applied Gothically or Classically, is the just proportion between the aisles and nave—the unbroken height of the lengthened vistas, and the effect, is wholly lost if all be thrown open together on the one hand, or choked-up with carpenter-like contrivances on the other.

I doubt not, with a little care, galleries might assist the general effect, instead of the contrary, as at present; and still retain their acknowledged qualities of usefulness and saving in expense.

MR. STEPHENSON AT BERNE.

The Swiss Federal Council have certainly pitched upon the best expedient for settling the important question of their system of railways, by calling Mr. Stephenson to a sort of professional consultation. Mr. Stephenson, accompanied by his assistant, Mr. Swinburn, had the whole mass of plans, sections, and estimates laid before him, as well as statistical tables relating to population, the amount of traffic, &c. The English engineers, accompanied by M. Councillor Näff, have also made a tour of inspection through the east and middle of Switzerland, and are about to proceed to the new projected lines of the west. As far as the opinions expressed by Mr. Stephenson have become known, they are as follow. He does not think it advisable to cover the whole of Switzerland at once with a network of rail, but to begin rather with a few central lines, which would bisect the land from east to west, and north to south. These are to be undertaken by the federal government, while the branch lines, which have subsequently to connect those main arteries, are to be executed by the single republics (cantons).

Mr. Stephenson has been gratified by the geological fact, that in the direction contemplated (that of the equator and the meridian), the longitudinal stream valleys of the Alps are favourable to the project, whose rise and fall do in no case exceed 1 in 100.

In a financial point of view, it is Mr. Stephenson's opinion, that the less capital employed, the greater the dividends are likely to be. He proposes, therefore, only single lines of rail; with the avoiding of costly tunnels, viaducts, cuttings, &c., and the accommodation of the line to the most adapted terrain of valleys and the slopes of hills. Further surveys have been made at Hauenstein, according to which inclined planes and compensation engines are to be put in operation at Laüfelfingen and Trimbach, and the tunnel of 2500 yards in length, projected by M. Merian, is to be finally executed.

It has not, however, been Switzerland alone which has honoured, on this occasion, the English engineer with particular confidence: the King of Sardinia has also commissioned M. Negrelli to meet Mr. Stephenson, for the purpose of consulting with him on the projected new lines over the Alburn, the Grimsel, and the Brüning. Mr. Stephenson seems, however, to be altogether averse to the idea of the gigantic tunnel—if anything can be called gigantic because it is impossible. Even the Lukmanier tunnel of 17,000 feet, seems to him an adventurous undertaking, and he prefers the passing of the mountain at St. Maria by means of compensating engines and covered galleries. It is, therefore, easy to foresee what Mr. Stephenson will say to a project, by which the passage from Domo d'Ossola into the Valais is to be effected by a tunnel of one-quarter of a league; that of the Grimsel by one of half-a-league; and the Brüning by one also of one-fourth league in length. L.

ON DEDUCTIONS FROM METEOROLOGICAL OBSERVATIONS.

On Deductions from Meteorological Observations. By JOHN DREW, Esq., F.R.A.S., Member of the Council of the British Meteorological Society.

(*Concluded from page* 312.)

Mean Temperature.—Diurnal Range.

THE mean temperature of a month or year has heretofore been considered the arithmetical mean of the highest and lowest readings of the thermometer recorded during that period; thus it was thought, that if the maximum and minimum readings were added together, and divided by the number of observations taken during the time, the result would be the mean temperature for the period through which the register extended. Mr. Glashier has shown, however, that this estimate would be too high by a quantity varying with the month during which the observations were taken.

At the Royal Observatory, Greenwich, meteorological observations have been registered since 1840, every two hours, throughout the day and night. If the times of observation are taken as abscissæ, and the temperatures be projected as ordinates, that is to say, if a sheet of paper be divided into 24 parts, each representing an hour, and at each point perpendiculars be erected which shall be proportioned to the temperature of each hour, the line joining the upper extremities of these perpendiculars will represent the variation of the temperature during the day; the mean temperature will be represented by a straight line, which will cut off with the curve equal areas above and below.

In like manner, if the mean temperature of each month be projected, the mean temperature of the year will be represented by a line which shall satisfy the same conditions.

In the Philosophical Transactions, Part I. 1848, may be found a paper by Mr. Glashier, "On the Corrections to be applied to the Monthly Means of Meteorological Observations, taken at any Hour, to Convert them into Mean Monthly Values." In this he has shown, that to the mean of the observations taken during a month at any hour, a certain correction must be applied to deduce the mean value for the month. By a careful comparison of five years' observations, he has been enabled to tabulate these quantities, so that henceforth by applying them, the mean monthly value may be deduced from observations taken at any one hour during the day. Since the publication of these results, he has extended his comparison through a period of eighty years, during which observations on the temperature have been made at the apartments of the Royal Society, Somerset House, all of which he has taken the trouble to reduce; and he has found the same law of diurnal variation to hold good. The application of his corrections gives true results from the Oxford observations, and seem applicable to all places inland; but whether exactly the same quantities will suit every place in England, especially those on the coast, admits of a doubt; they certainly must be altered for Dublin, and for this reason, that the maxima and minima of meteorological phenomena do not occur at the same hour of the day, as at Greenwich; and the apex of the curve projected as above, denoting the highest temperature, is much more pointed; in other words, the greatest heat during the day is attained more suddenly, and declines more rapidly at Dublin than at the Royal Observatory at Greenwich. At the latter place, twice during the day, the mean temperature of the air is at its mean value, and these times are as follows in the several months:

		h. m.					h. m.	
In January	..	at 10 0	a.m.	..	and again	..	at 8 0	p.m.
In February	..	at 9 30	a.m.	..	and again	..	at 6 40	p.m.
In March	..	at 9 10	a.m.	..	and again	..	at 7 20	p.m.
In April	..	at 8 40	a.m.	..	and again	..	at 7 0	p.m.
In May	..	at 8 25	a.m.	..	and again	..	at 7 30	p.m.
In June	..	at 8 0	a.m.	..	and again	..	at 8 0	p.m.
In July	..	at 8 0	a.m.	..	and again	..	at 8 5	p.m.
In August	..	at 8 20	a.m.	..	and again	..	at 7 20	p.m.
In September	..	at 8 55	a.m.	..	and again	..	at 7 20	p.m.
In October	..	at 9 0	a.m.	..	and again	..	at 7 0	p.m.
In November	..	at 9 25	a.m.	..	and again	..	at 6 45	p.m.
In December	..	at 10 0	a.m.	..	and again	..	at 7 20	p.m.

At these periods the temperature changes very rapidly, or it might be advisable to take observations at the times above specified; but unless this were done with great precision as regards the local time, a small error in that particular would introduce a large one in the observations: it is, therefore, recommended, that the times of observation should be those least liable to interruption, and that they should correspond most nearly with those at which least changes are taking place in the elements, which times the tables will show.

If the mean of the daily registrations of the maximum and minimum thermometers be taken, the following quantities must be subtracted to obtain the mean temperature for the month:—

January	0·2°	April	1·8°	July	1·9°	October	1·0°
February	0·4	May	1·7	August	1·7	November	0·4
March	1·0	June	1·8	September	1·3	December	0·0

We have thus, then, two entirely independent methods of determining the mean temperature, which mutually check each other. One, from the mean of the highest and lowest readings of the thermometer minus the above quantities; the other, by applying Mr. Glaisher's corrections to the observations taken at any hour of the day. The first publication of the British Meteorological Society is a reprint of these tables, with the addition of another, showing that the amount of cloud is also subject to certain laws, and that the obscurity of the sky has its maxima and minima and mean amount as well as the temperature of the air. Not that these are the only variable elements in meteorological inquiry which obey definite laws; the mercury in the barometer fluctuates daily above and below the mean pressure, which may be ascertained by the application of the tabulated corrections. Four times daily the reading of the barometer is at its mean value: these times in the several months are as follows:—

		h. m.	h. m.	h. m.
In January	at midnight	at 8 0 a.m.	at 0 40 p.m.	and at 5 0 p.m.
In February	at midnight	at 8 0 a.m.	at 1 40 p.m.	and at 6 20 p.m.
In March	at midnight	at 7 35 a.m.	at 1 50 p.m.	and at 6 0 p.m.
In April	at 1 0 a.m.	at 6 40 a.m.	at 1 40 p.m.	and at 7 20 p.m.
In May	at 1 0 a.m.	at 8 20 a.m.	at 1 0 p.m.	and at 8 0 p.m.
In June	at midnight	at 4 20 a.m	at 1 40 p.m.	and at 9 20 p.m.
In July	at 1 0 a.m.	at 6 25 a.m.	at 1 40 p.m.	and at 8 45 p.m.
In August	at 1 0 a.m.	at 7 0 a.m.	at 1 10 p.m.	and at 7 35 p.m.
In September	at 1 0 a.m.	at 7 30 a.m.	at 1 0 p.m.	and at 7 0 p.m.
In October	at 0 25 a.m.	at 7 50 a.m.	at 1 10 p.m.	and at 5 0 p.m.
In November	at 1 40 a.m.	at 8 20 a.m.	at 11 40 p.m.	and at 5 45 p.m.
In December	at 0 40 a.m.	at 7 40 a.m.	at 0 45 p.m.	and at 6 5 p.m.

By the application of the quantities in the tables, all of which have been deduced from observation, the following phenomena may also be reduced to their mean values:—

1. The mean depression of the temperature of evaporation below that of the air at the height of 4 feet above the soil at every hour in each month.

2. The mean depression of the temperature of the dew point below that of the air.

3. The corrections to be applied to the monthly mean elastic force of vapour, to deduce the true mean elastic force of vapour for the month from the observations taken at that hour.

4. For the mean quantity of aqueous vapour in a cubic foot of air.

5. For the mean degree of humidity.

6. To the weight of vapour in a cubic foot of air.

I trust that the explanations I have attempted will show that some progress has been made in the study of Meteorology, and will convince observers that their records may be of service in the cause of science, that they will excite an interest in inquiring minds, and direct their energies in a useful channel. It is incumbent on the engineer not to neglect the science which may assist him in supplying the increased demand for one of the necessaries of civilised life. The medical practitioner—the recognised guardian of the public health—the mariner, on whom rests the responsibility of preserving life and property in crossing the ocean, and whose experience has taught him the necessity of marking atmospheric changes, cannot, with safety, disregard the science of Meteorology. The British Meteorological Society is intended to form a depôt for the valuable observations of the officers of the navy and mercantile marine; and that society will, I apprehend, soon enter upon some systematic arrangement for the purpose of gaining over such intelligent and competent allies. The agriculturalist is deeply interested in our progress, in order that his skill may be exercised in developing those natural productions which are best suited to the climate of the country he is called to cultivate. On this latter point I may appropriately quote the words of a late writer in the Royal Agricultural Society's journal, who has taken up the subject with, great ability in an article 'On the Climate of the British Islands in its Effects on Cultivation.'

"Of what avail, then, it may be asked, is the knowledge of such a subject? That we may bend to the power we cannot control, and learn to adapt our culture to the capabilities of the climate indeed, climate is the ruling principle of agriculture—the law which governs the productions of different countries; and he who yields the most enlightened obedience obtains the largest reward."

For the guidance of those who are interested in meteorology, I subjoin the results of my observations for the last quarter, in the form in which I usually print them for private distribution.

Results deduced from Meteorological Observations.

Taken at Mr. Drew's Observatory, Cumberland-place, Southampton,

At 9 a.m., 3 p.m., and 9 p.m. daily, during the months of April, May, and June, 1850.

Latitude 50 deg. 54 min. 34 sec. North; Longitude in time 0h. 5m. 37·7 sec., West. Height of Barometer above the mean level of the sea, 55 feet; of the Thermometers above the ground 4 feet 9 inches: aspect North.

	April.	May.	June.
Mean height of the Barometer corrected and reduced to the temperature of 32 deg.	29·755	29·906	30·052
Tension of aqueous vapour in inches	·315	·359	·427
Pressure of dry air	29·440	29·447	29·625
Deduced dew point	45·	48·9	53·9
Weight of vapour in a cubic foot of air (grains)	3·6	4·08	4·8
Required for saturation (grains)	0·82	0·74	1·73
Degree of humidity, complete saturation being 1	·814	·822	·760
Weight of a cubic foot of air (grains)	534·5	531·	547·
Greatest heat	65	73·3	82·
Least heat	36·2	30·3	39·8
Range of the Thermometer	28·8	43	42·2
Amount of rain in inches	4·731	2·265	3·099
Number of days on which rain fell	20	12	9
Highest reading of the barometer	30·337	30·259	30·374
Lowest " "	29·094	29·379	29·460
Mean temperature from the 9 a.m. observations	49·9	51·8	60·2
Ditto 3 p.m. ditto	47·9	51·6	59·7
Ditto 9 p.m. ditto	48·8	52·4	59·6
Mean of the three	48·8	51·9	59·8
Mean of the maxima	56·9	60·7	71·5
Mean of the minima	44	46·8	51·4
Mean temperature deduced from these	48·9	53·	59·6
Strength of the wind	·63	·29	·2
Amount of cloud	·7	6·6	4·4

For the explanation of the mode of deducing the mean temperature, see Mr. Glashier's paper in the Philosophical Transactions, part 1., 1848.

In estimating the amount of wind, a calm is represented as 0, a gale 6.

In estimating the portion of the sky occupied by clouds, a blue sky is represented by 0, a clouded sky by 10, at the time of observation.

In the deduced results, which will be found useful for comparing the climate of Southampton with those places from which reports are sent to the Registrar-General, the Barometer reading, when corrected, may be considered as showing the absolute height of the mercury at a mean temperature of 32 deg., after the application of various corrections, including one which reduces it to the Royal Society's standard, with which the instrument has been compared; but no reduction of the sea level has been applied.

For a full explanation of the various deductions, see Glashier's Hygrometrical Tables, and the Report of the Royal Society on Meteorology.

THE GOVERNMENT AND PUBLIC ENTERPRISE.

We have often had occasion to point out the manner in which the public interests are sacrificed by the government, more particularly as affecting public enterprise; but we know few instances more flagrant than that of the claim of "foreshore." Is a sand to be embanked?—a harbour constructed?—or a river improved?—in steps the claim of some government board for whatever land may be recovered. This obstructive policy proves fatal on many occasions; and the most valuable enterprises are abandoned. If the government really represented the public, and discharged the duties incumbent upon it, it would be the most proper agency for taking charge of land reclaimed, for the very simple reason that the government would, agreeably to its duty, recover every portion of surface which could be made contributory towards the national subsistence. The government of Holland thus takes charge of the defensive works, and from time to time reclaims large tracts of land, as is now going on in the Haarlem Sea. The government of England does nothing of the kind; no public work of reclamation does it carry out; from all does it take toll if it can. Not content with mismanagement of the houses, woods, mines, and lands belonging to the public domain, it sets up a usurping claim, that all reclaimed land and the whole foreshore belongs to the crown; whereas, historical evidence abundantly proves that the crown could have no such rights, and that if any such existed, they belonged to the townships, the community at large, or such members as took possession of waste and reclaimed it. By land, the public rights are contested by the government; and by river and sea the same invasion extends. If Stephenson proposes a bridge over the Menai, or Brunel one over the Severn, the Admiralty steps in and prescribes conditions supposed to be impossible of fulfilment. Indeed, the conditions proposed to Robert Stephenson might have figured in the Thousand and One Nights, or the collection of the Comtesse D'Anois, as those proffered to some laborious gin or subtle fairy.

The reclamation of land is proposed in the Wash, Morecambe Bay, the Duddon, Loughs Swilly and Foyle, the River Dee, Langston Harbour, and many others. Yet, who knows of any countenance given by the government to undertakings which will add to the country one hundred thousand acres of the richest soil, and yield food for nearly half-a-million of people? The Norfolk Estuary plan, now at length about to be begun, requires only a relatively small capital; but so far from the government contributing towards the funds, it has been the obstacle in the way of their being raised The corporation of Lynn contributes 60,000*l.*, the landowners of the neighbourhood a large sum—but what does the government contribute? Here, six and thirty thousand acres will be brought under cultivation, and the cultivation and navigation of millions of acres in the upland will be improved. This is a case, one would think, urgent on the government of a rich country, and which levies such a large amount of taxes for unproductive purposes.

Look at Birkenhead. There the government actually attempted to mulct the parties of 100,000*l.*, although it had refused to contribute a halfpenny towards the reclamation of the foreshore to which it propounded a title.

In the instance of Morecambe Bay—which, though not the original project of George Stephenson, remained his favourite undertaking to the last day—when it was proposed to reclaim above thirty thousand acres, and when even the freeholders and lords of the manner had given way; when the Duke of Buccleuch and the Earl of Burlington had given their sanction, the two government departments of the Woods and Forests and the Duchy of Lancaster, each set up a conflicting claim to the whole, and the Admiralty interposed to set up hindrances. All the noble lords, and others promoting the undertaking, could get from the government was, that they might reclaim the land if they got the consent in parliament of the Woods and Forests, the Duchy of Lancaster, and the Admiralty; and the government would then see what it would take as its share. This was so futile that the promoters of the plan were at that time forced to abandon it.

The result was this, that whereas an embankment carried right across the bay would have borne a short line of railway, and taken in a great area of soil, the railway actually made has been successively altered in its plans, so as to hug the land, and sacrifice the original objects of the project.

Lough Swilly and Lough Foyle present no more encouraging results. A considerable sum has been expended; but though a small amount of government aid would ensure success, the undertakings remain in abeyance. Solvent contractors are willing, on low terms, to execute the necessary works for embanking the slob; but in the depression of all public undertakings the company cannot obtain capital, and the government will not lend it.

At present the government is engaged in a long Chancery suit, to wrest from the Corporation of London its long-possessed jurisdiction over the banks and bed of the river Thames; though no one thinks the government would manage the river better than the corporation. Indeed, had the latter the proper powers, it might effect the embankment of the river throughout its course, and remedy evils which are attributable solely to the obstructiveness of the government, which does not leave freedom of action to the corporation.

Half-educated politicians may doubt the value of railways, canals, docks, harbours, and other works, which they consider only promote distribution; but they are forced to allow that every acre added to the surface of these islands is an addition to our means of production. To increase these means of production is one of the first duties of a community and a government: and no practical man who has ever examined the question fails to recognise that abundant opportunities exist for the proper application of the labour and resources of the nation on many parts of our coasts. So long, however, as the fictions of lawyers, and the unfounded claims of government departments are allowed to stand in the way, these resources must remain in abeyance, and the progress of improvement limit itself to the single or few fields reclaimed by the landowner, who is not forced to come into contact with the government or the legislature. The present state of matters constitutes a grievance which prevents the application of hydraulic engineering and the development of the national resources.

ORDNANCE SURVEY OF SCOTLAND.

Our attention has been called to the present state of the Ordnance Survey of Scotland, by a very able article in our Edinburgh contemporary, the *Scotsman*, and it induces us to claim the public consideration on a matter of very considerable professional interest. In London we have been interfered with by the military surveyors, and, it is now known, to the public prejudice. Those who objected to it at that time were considered factious, and perhaps we may be so called for referring to it now, but there are too many commissioners and jobbers at large not to make us wary; and we think it necessary to warn the public, from the experience of the past and the example of the present, against trusting anything more than they can help to the direction of the government and its boards. Edinburgh and Scotland are not better off than London—the Ordnance Surveyors are behind time; and if the present course is to be followed up, there is no telling when the Survey may be completed. The British Association in its meetings in Scotland has had some influence in urging the Ordnance to the work. Every meeting is marked by impatience at the non-completion of the Survey. In 1834, sixteen years ago, when the Association formerly met in Edinburgh, they urged this question on the attention of the government; and we must own it marks a degree of apathy to the wants and interests of the country, that in 1850 a meeting should have again to move on the same question. In the "Synopsis of Recommendations" handed to members on the last day of the Association, was the following notice:—

"That a committee, consisting of the President, the Duke of Argyll, Sir R. I. Murchison, Professor J. Forbes, and Lord Breadalbane, be appointed for the purpose of urging on her Majesty's government the completion of the Geographical Survey of Scotland, as recommended by the British Association at their former meeting in Edinburgh in 1834."

Those who know what government boards are, will not expect too much from this strong hint; and the *Scotsman* particularly remarks this, and urges the necessity of public bodies and private individuals following up the demand. It says:

"Notwithstanding the well-known energy and influence of the members of the above committee, the last line of the resolution does not permit us to hope that it will effect much good, unless followed up by similar and more continuous efforts on the part of other individuals and public bodies. Had the sixteen years that have elapsed since the former recommendation been rightly employed, this resolution would not have needed to appear in the proceedings of the Association."

No one will be surprised to learn that in sixteen years nothing has been done. A great part of the map might have been completed, and the remainder so far advanced as to give us some hopes of living to see its termination. Instead of this, only a few sheets of one county have been finished; and at the present rate of progress, it is computed half a century will be required before a complete map of Scotland is produced. The Ordnance Survey of Scotland and the British Museum Catalogue may perhaps be finished at the same time; and if not out of date in their earlier portions, be of use to our great-grandchildren.

We are informed, that all the great system of triangulation is completed, and that the work which now remains to be done is merely the filling-in of the subordinate details. Every body knows men capable of performing this work can be procured in any number, and for very moderate pay—as the Ordnance Surveyors of the metropolis, the corporals and privates, can give evidence.

The way in which this system of management works is most sickening: it not only does not the good it professes to do, but hinders others from doing good. Our contemporary gives flagrant proof of this. He says, the Government Survey is the great barrier to any attempt at the improvement even of the local maps. No publisher dare venture on the expense of a new survey, or even on a thorough collation of the existing materials for correcting the map, with the fear of a government map before his eyes. We agree with him, that private enterprise would long ago have produced a more perfect map, and that the speculation would have been successful, had not the public survey stood in the way—like the dog in the manger, neither eating itself nor allowing others to do so. Were it fully understood the Scotch are to have no government map for the next twenty years, even yet private enterprise would undertake it; but no publisher is safe in surveying even a single county or correcting a single sheet of a map. In example of this is quoted the case of the survey of Edinburgh, by the Messrs. Johnston—which was no sooner completed on the government scale, and the first sheet published, than the official surveyors were brought down from the extreme south of the kingdom, and the whole work begun anew at the public expense.

THE SHIPBUILDING TRADE OF LIVERPOOL.

Liverpool is forced to be great, not only by her own progress, but by the rivalry of Birkenhead; and the public can never be surprised to hear of any gigantic enterprise in which she has engaged. Her docks and warehouses are among the wonders of England; but she contemplates new works, on which the *Liverpool Times* speaks at length:—"No one can read," says our contemporary, "the evidence taken before the Committee on Shipbuilding without perceiving, that in obtaining the indispensable object of a sufficient supply of dock accommodation, we have sacrificed the highly-desirable object of a sufficient supply of accommodation for shipbuilding. The only manner in which these two objects could have been combined without forming a great number of new docks, and setting aside new land for the shipbuilders, would have been by adding to the real amount of dock accommodation, by building warehouses round the already existing docks, and by introducing other means of economising dock space, connected with that grand improvement, and altogether impracticable without it. Had this been done when it was proposed by Mr. Eyre Evans, not only might Calcutta ships have been discharged in three or four days, instead of three or four weeks (as Mr. J. A. Tobin says they now are), but all other ships might have been discharged at the same rapid rate. Thus, very few new docks would have been necessary; and Mr. Wilson, and the other shipbuilders, might have retained their building yards, for another generation at least. Unfortunately for the town, that proposal was defeated by personal interests, combined with party spirit; and having been defeated, there remained no other means of providing for the rapidly increasing commerce of the port, than by forming a great number of new docks. This could not be done without expelling the previous occupants of the land on which they had to be formed. Thus the refusal to build warehouses round the docks rendered the forming of new docks necessary; and the taking of ground for them has pretty nearly annihilated the shipbuilding and engineering of the port, and has diminished to an enormous extent the amount expended in the town in wages."

This affords a very clear view of the difficulty in which Liverpool is now placed; but it seems by a remarkable instance of retributive justice, the opponents of dock warehouses have been amongst the principal sufferers from the course of proceedings which they rendered necessary. The closing of the ship-yards, and the diminution of the amount of employment in the foundries, have had the effect of emptying thousands of houses, and of adding frightfully to the pressure of poor-rates, both on warehouses and houses.

The tonnage of the port has nevertheless increased from 1,223,318 tons in 1836, to 3,309,746, in 1849. There were only two ways of meeting this increase; the one to make the existing docks do double or treble duty by improved modes of working; the other, to form a multitude of new docks. The former course being rejected, nothing remained but to adopt the latter.

It is well observed, that what renders Birkenhead formidable to Liverpool, is the admirable arrangements made for landing goods, and forwarding them into the interior. There the warehouses are so built that goods can be craned up from the holds of the vessels which import them, on one side, and lowered into river boats, or railway trucks, on the other. At Birkenhead there will be no cost of cartage on goods sent at once into the interior; no danger of pilferage; no unnecessary loss of interest on ship or cargo, and no loss of a favourable market or of a handsome freight.

With regard to the plan proposed by the Shipbuilding Committee, and explained in the Town Council by Mr. J. Aspinall Tobin, we understand it to be, that the present building yards should be made as convenient as possible, and that fourteen new building yards, each containing about 10,000 square yards of land, should be formed north of the Sandon Dock. These are to be furnished with private graving-docks, at the cost of the Corporation, the tenants paying five per cent. interest on the cost of the graving-docks, and 8*d.* a-yard rent for the land; and being secured in the possession of the land by leases long enough to induce them to erect first-rate machinery for shipbuilding, and the necessary buildings.

GERMAN ARCHITECTURE.

The capital, fig. 1, belongs to a column supporting the roof of the Great Hall, called Land Grafenhaus, Wartburg, Germany. It is of the 17th century, and should be deemed perfect in originality of design; without being much undercut, it is deeply wrought. We trust this beautiful specimen may in some way prove suggestive.

The capital, fig. 2, is from the remains of the choir in the Church of St. Peter and Marcelliu, Seeligenstadt, Germany, and may be considered remarkable for its elegant and beautiful proportions in any age, but the more so when we are told it dates as far back as the 13th century.

CHARLES THE SECOND'S BATH, BATH STREET, NEWGATE STREET.

Sir Christopher Wren, Architect.

(*With Engravings.*)

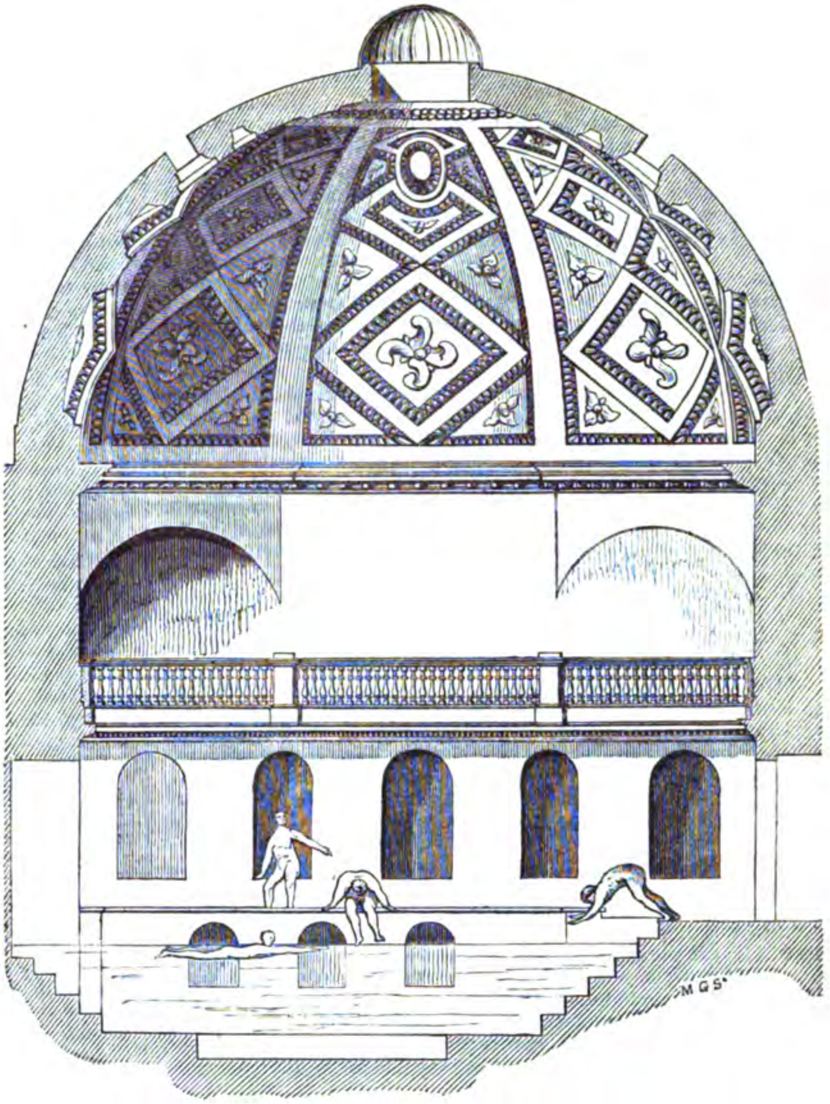
To be whirled along the surface and through the bowels of the earth, with fearful velocity, by the strength of a creature of men's formation, docile as a horse, feeding on flames and boiling water, is not the only novel feature of society at the present day; the desire on the part of the masses to move fast and indulge a commercial spirit on a gigantic scale, is accompanied by a love of cleanliness and a disposition to extend the means of relaxation and healthy enjoyment: thus, Baths, with those useful concomitants Wash-houses, are fast springing up for the use and wholesome recreation of the hard-worked million. The term novel, can indeed, be rigorously applied only to one of the above-named features, since the erection of Baths on so large a scale as to warrant the appellation of "national," is nothing more than the revival of a very ancient custom. That the "rail" is in its infancy is a true and trite remark; what may be its true character when it has reached maturity, none can predict; time alone can unfold the mystery: but with respect to "Baths," we know what has been done by the ancients. On the score both of utility and splendour, the baths of the Romans left nothing to be desired; it were in vain to hope to eclipse them. "In those buildings, Architecture developed all her resources, and robed herself in a profuse display of the most costly materials; therein it distributed in an orderly manner, the choicest productions of art, and by the application of columns, and other architectural details, all ingeniously contrasted, it produced in one immense design the most striking and varied effects. It offered, in the interior especially, decoration of the most fascinating as well as of the most imposing character, whilst it displayed externally all the sumptuosity of amphitheatres, vast terraces, porticoes, and delightful gardens."

We see, then, that with respect to such buildings, we are yet some way behind; but we also see plainly what we have to achieve; and, with the energies of Englismen is it too much to imagine, that we may ere long rival Rome in our Baths?

It has become the fashion to anticipate time: 1850 seems fairly to be forgotten in the vehement desire which all are seized with to behold the giant offspring of 1851. In obedience then to the fashion of the times, let us contrast the National Baths of 1850 with what similar establishments may possibly be in 1860. Piercing then through the veil of time, we see the Bath having become the popular feature of the day: Baths—not merely troughs in which to wash the body, but establishments in which the intellectual as well as the physical wants of man are ministered to. Complicated buildings, wisely planned, covering immense areas, in which are united all things necessary to the complete unbending of the body and mind; in which, moreover, the fullest scope is given to the display of the arts—of the leading arts of painting and sculpture especially; structures in which much is combined for the mental training as well as for the bodily recreation of masses of beings deprived of other means of acquiring polite instruction, through the necessity imposed upon them of daily toil. This too faint a glimpse at the development of so important a feature as that of the Bath, supposes the exercise of much taste and judgment, if not of genius, in the supervision of such a scheme. If it be true that many circumstances combine to render it not improbable that the construction of Baths will become a favourite subject with the English, then is it well that we should familiarise ourselves by times with good models on which to shape our future plans; and it is gratifying to know, that however advisable it is to consult foreign examples for such a purpose, we have matter of the kind at our own doors worthy of the greatest attention.

To no greater teacher of architecture can we go than to Sir Christopher Wren; and to a Bath designed by that great architect is the attention of the reader now solicited. The Bath in question was erected for the use of King Charles the Second, and stands at the end of Bath-street, Newgate-street, in the neighbourhood of St. Martin's-le-Grand.

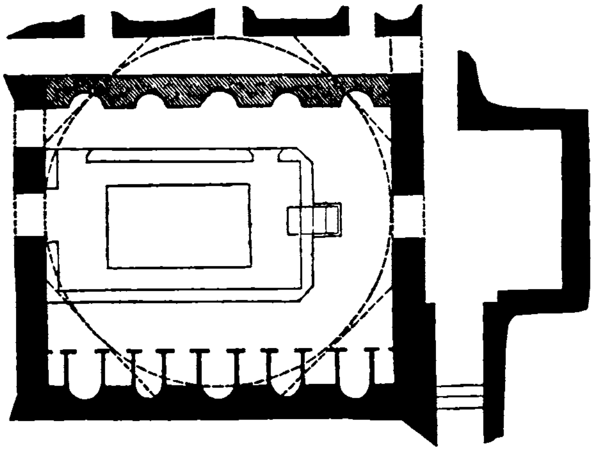
The boundary walls of the bath form a square: the dressing closets and the seats are made to project on the right and on the left into the chamber, and are surmounted by a balustrade, which is carried round the whole of the interior. At the back of the seats is a passage communicating with private baths; the dressing closets abut against the boundary wall. Above the balustrade the



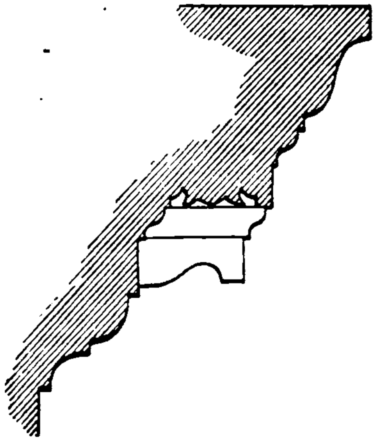
chamber is worked into an octagon by means of arches at the angles of the boundary walls, and the whole is crowned by a hemispherical dome. The floor of the bath is paved with marble slabs, and the sides, up to the balustrade, are lined with Dutch tiles. The dome is of brick, ornamented with coffers executed in plaster.

To the uninitiated alone is it necessary to remark, that Sir C. Wren has invested his buildiing with an appropriate character; the interior, which is beautiful, is stamped with an air of tranquility and cheerfulness highly characteristic of the use to which it is designed. Not only is the general scheme admirably conceived, but every detail, both for usefulness and beauty, minutely attended to; thus, the niches in the room itself are ornamental seats; those in the sides of the plunging bath are principally for the purpose of breaking the action of the water, and preventing the latter from spreading into the room when agitated by the bathers; rings, for the purpose of holding-on in the water, are so placed as to become real ornaments. A well-modelled lion's head conceals the spout which admits the flowing stream; another similar head masks the opening to a drain which conveys away all grease and oiliness which are apt to collect on the surface of a bath. There was originally no aperture in the wall of the chamber to admit light; hence a sense of security as well as of seclusion was created, by which the pleasure of the bath is greatly enhanced; the dome—gracefully panelled—alone admitted the light. The cornice to the chamber bears the impress of thought and study, the individual mouldings being so modified as to render them applicable to an interior *only*. In short, to whatever point our attention is directed in this unpretending and charming building, studious care and propriety of motive are conspicuous, and, like all the works of Sir Christopher Wren, this building of 200 years' standing is still a model to future times.

To many this bath is well known, it being in full operation: to too many it is unknown. The publication of the building may therefore be considered in some respects as a disinterment of a monument of taste and utility. The City of London abounds with hidden ornaments of this kind. As the ivy is wont to grow round noble trees, veiling the beauty of the latter, so many noble structures of by-gone times are concealed by the brick and mortar incrustations of this latter age; and as it is the duty of a vigilant gardener to free the stems from parasytical plants, so is it the duty of the architect to pierce through those excrescences which, through time and necessity, have encumbered the choice fruits of architectural genius.



Plan of Bath.



Profile of Cornice.

A. W. Hakewill.

London, *October* 10*th*, 1850.

CHAPEL ARCHITECTURE.

Chapel and School Architecture, as appropriate to the Buildings of Nonconformists. By the Rev. J. F. Jobson. London: Hamilton, Adams, and Co. 1850.

The clerical title attached to the name of the writer may lead some of our readers to take him for an amateur; but it seems Mr. Jobson was articled, at Lincoln, to Mr. Edward James Willson, F.S.A., and left the drawing-board for the Wesleyan ministry; nor has he since been totally disconnected from architectural pursuits, having been for many years secretary of the Wesleyan Chapel Building Committee. In this capacity he has rendered some service to architecture, having greatly influenced the movement for building chapels in the Gothic styles, and of more architectural character, and having published several articles on the subject in the *Watchman* newspaper, which now form the beginning of the work before us.

These observations will cause our readers to feel a greater interest in the work, and will enable them to judge of its especial tendency, which is to promote improved architecture, and the employment of the mediæval styles, at the same time giving such counsel to the ministers and other officials interested as may enable them to co-operate with the architect, and obtain an efficient building. We may hereafter have occasion to notice Mr. Jobson's remarks, advocating and enforcing the necessity of strictly acting under professional advice in all structural operations.

Mr. Jobson very naturally introduces his subject by an appeal to the higher emotions, of which religious architecture is the exponent, and sympathy with which is too often lost sight of by many well-intentioned but little reflecting persons.

"What surpassing power there is in the mere theme of religion to impel human energy to its highest efforts, and to enable genius to transcend the artistic description of merely mortal concerns, let the immortal poem just quoted testify. The greatest triumphs in music—the 'Messiah,' with its unequalled grandeur and pathos; the 'Israel in Egypt,' with its overwhelming choral magnificence; the 'Creation,' with its elevated joy and rapt sweetness; the 'Mount of Olives,' with its wondrous sublimity,—all bear witness to the might there is in the theme of religion to raise and sustain the powers of genius in its noblest exercises. The most perfect achievements of the pencil—those of Raffaelle, and Michael Angelo, and Leonardo da Vinci—verify the same position. Sculpture is an art which, in modern times, has been merely imitative of ancient models; and those models of perfectness were, notoriously, connected with religion. Ancient poets, like ancient sculptors, consecrated their best efforts to religion; and seemed, indeed, as if they dared not to begin to sing without invoking the aid of Divinity, under such imperfect conceptions as they had of the Divine Nature and existence.

"The writer of these remarks is, nevertheless, not pleading for a high style of elaboration and ornament in the erection of Wesleyan Chapels. He is prepared to maintain that they should have *no unnecessary* adornment. Let open spaces for hearing the word of God, and for prayer be inclosed with walls and roofs. But, however plainly constructed, our chapels should be of suitable forms and in good proportions; these will not increase their cost. Simplicity, rather than profuse elaboration, is the characteristic of beauty. Deformity shocks the universal taste of civilised man. How symmetrical, how simple and pleasing in their forms, are all the works of God!"

Our writer next discusses the question of style, and his predilections, as much as anything else, lead him to the preference of the mediæval styles, for which he is an enthusiastic votary.

"A Methodist Chapel is a place for Christian worship. If then, any style of architecture can be shown to have arisen out of the Christian religion, and to have been moulded by, and associated with it, from early times, so as to have become the outward and visible representation of Christian worship,—it is reasonable to say that such a style should be preferably selected; more especially if it can be shown that this *Christian* style of architecture is not inferior to any other style ever devised; that it is not more expensive; and that it is better adapted to the country and climate in which we live. Such a style is that usually called 'Gothic.'

"Gothic architecture is Christian architecture, as distinctly and emphatically as the Egyptian, Greek, and Roman, are Pagan.

"Grecian architecture was, in its origin, wooden. It was first composed of trunks of trees, with lintels laid across the top, and with rafters resting upon them. These were afterwards covered with ornaments; and when the Greeks came to employ marble and stone for building, they retained the same wooden type, and even moulded and carved their ornaments to represent the beam ends, and the wooden finish they originally made. Besides, a Grecian temple was made for offering animal sacrifices. The priests, only, went within, while the worshippers remained *outside*. The interior was comparatively small and dark, being only lighted from the top; and if, in professed imitation of the true classic model, windows be made in the front and at the sides, and the interior be large, seated. and galleried,—the proportions and beauty of a pure Grecian building must be violated.

"Again, the roof of a Grecian building is low. A high pitch was not required in the climate of Greece. With us, roofs must be constructed so as to resist the weather, and most readily throw off snow and rain; so that a much higher pitch of roof is required."

The next point Mr. Jobson proceeds to urge on the Wesleyan body is a very important one—the question of expense; and his remarks will not fail to command the attention of architects, because this is one of the points on which they are often called upon to do battle in the cause of their art. Mr. Jobson contends, and all practical men will go with him, that good architecture is, at any rate, not more costly than bad, and that, indeed, the balance is against the latter. He shows, moreover, that whatever false economy may plead, the paid services of a good architect are better than the unpaid and voluntary services of no architect, or of an amateur, however well meaning. His remarks are—

"In adopting Gothic Architecture, we need not be inconsistent with our professed form of Christianity, as Protestants, and Methodists.

"But it may be said that Gothic Architecture, while appropriate in the erection of churches, is not so as to chapels; and being, as it is generally supposed, much more expensive than the Grecian or Roman style—that is, if carried out in all its details—it would be imprudent for Methodists, who have no 'government grants' for chapel-building; who are not partakers of 'Queen Anne's bounty;' and who have no landed property to support their fabrics with the necessary repairs, to adopt such an unsuitable and costly style. The answers to such objections are brief and decisive. The Gothic style of architecture is as fully suited to chapels as to churches, and much more so than either Grecian or Roman. These 'classic' styles, as already shown, must be barbarously interfered with, in their proportions, to place tier above tier; to make numerous openings, both in the front and sides, for windows; and to cover the whole with a roof of such a pitch as to be suitable to our climate. On the other hand, Gothic architecture admits of expansion or contraction to any extent. It may be as lofty in its erections, or as low as we please. It may be simple and economical in its forms, as in the Early English—moderately ornamental, as in the Decorated—or elaborately adorned, as in the Perpendicular. It has models, from the plainest chantries, which are small in their dimensions, to the spacious and sumptuous chapels of St. George's, Windsor—Henry VIIth's Chapel, Westminster—or that of King's College, Cambridge.

"And, as to *Expense*, it is a mistake, fostered by prejudice, to suppose that Gothic Architecture is necessarily more costly than Grecian or Roman. In the forms most frequently employed in the erection of ecclesiastical buildings, it is the cheapest. The District Church Building Committees, and the Free Church of Scotland, have proved this for themselves. And the Methodists have *proved* it. The Model Plan Committee, appointed by the last Bristol Conference, applied to six of the most able architects, residing in different parts of the kingdom, for designs, specifications, and estimates, in their quantities and prices, of a chapel to accommodate seven hundred and fifty persons, in Gothic, Grecian, or Roman styles: each architect to supply two designs—one in Gothic, and the other in Grecian or Roman—with their estimates. The result was, that in *every* case, the estimated cost of the erection of the Gothic design was *less* than the estimated cost of the others; and, in some instances, considerably less. And this is what might be expected; for one great recommendation of Gothic Architecture is, that it employs no unnecessary forms *merely* in the way of ornament, as other styles do. It requires no expenditure of 500*l.* on five or six heavy and lofty columns to support nothing, as does Pagan Architecture. I know of one Grecian front of a Methodist Chapel which must, with its quadrangular tiers of columns and entablature, and with its flight of numerous steps (necessary for its elevation, but most dangerous in frosty weather—and, at all times, difficult for the aged), have cost as much as all the chapel besides. And I could name another Grecian Chapel in Methodism that had no less than 500*l.* expended on its fluted-columned recess for the Communion-Table, almost wholly hidden behind the Pulpit and the Reading-Desk; and which Chapel left the Trustees with a debt, that by its many thousands, has oppressed them most grievously. But I forbear, for while I write *freely*, I must not even seem to condemn good and generous men, who, in their great zeal for God, committed, unintentionally, some improprieties.

"Gothic Architecture requires no such extravagant outlay for ornament. All its ornaments are parts *necessary* for the strength and convenience of the building. Its buttresses support and strengthen the walls, and make them as strong as if twice as thick. Its mullioned windows prevent the blinding glare of a mass of light, such as shines in a large Grecian opening. Its pillars, if within, support the middle roof, and hold fast the gallery. Its pinnacles, by their pointed forms, throw off the wet from the buttresses, and prevent injury; and its parapets, cornices, and basement-mouldings, are all, if properly employed, conductors of water from the building. It requires no artificial accompaniments—such as do-nothing front gables with blank windows and with iron bar supports behind. It is—incontrovertibly—the most *consistent* and the most *economical* style of Chapel Building that can be employed."

It will be seen Mr. Jobson does not rely upon theory or upon arguments *à priori*, but he appeals to the experience of facts; and besides those already adduced, he gives abundant evidence in the course of his work that he does not speak without authority.

Lately, in noticing a chapel, we had occasion to point out that the requirements of the congregation were not always so well attended to as in the design to which we were referring; and we are glad to have the opportunity of referring those architects who wish information on the subject, to the pages of Mr. Jobson's book. This writer remarks, that the nature of the accommodation required was a subject which particularly attracted the attention of the Building Committee appointed by the Wesleyan Conference in 1846. He says:—

"It appeared to the committee that, in preparing to erect Wesleyan chapels, sufficient consideration had not generally been given to the want of *Class-rooms* and *Vestries*. These are indispensable to the working of Methodism in the present day. Formerly, they were less needed than they are now. In the past time, classes were scattered, as to their places of weekly meeting, throughout a city or town; but, of late years, there has been a growing feeling towards meeting for weekly fellowship on the chapel premises. Class-rooms on chapel premises must, in the present day, to a much greater extent than formerly, be provided. In addition to these, it is also requisite that, in connection with a chapel of considerable dimensions, at least one larger room for *prayer-meetings* and *social gatherings* should be supplied. The increased agencies of Methodism require this. Of course, additional buildings will require additional expense; and it is important that ministers and trustees, in their first meetings for the erection of a new chapel should consider that, as Methodists, they have not only to build a chapel, but also vestries, class-rooms, and a larger room for prayer-meetings, annual or other tea-meetings, &c.

"Another consideration which engaged the attention of the committee, was *the arrangement of the buildings in such a manner as most easily to admit of enlargement when required.* And the committee found, by applications to practical men, that it would be easy, generally, to provide for enlargement, by including the class-rooms, and the larger room over or below them, under the roof at the farther end of the chapel. On this plan, the roof not having to be disturbed, it would be necessary only to take down the wall behind the pulpit, and the floor and cross-walls of the rooms behind; and then the chapel would be enlarged."

This latter consideration is one very important and applicable to churches, as well as to many classes of public buildings; where, in consequence of its neglect, very serious and needless expense is in a few years created, or very great inconvenience submitted to, and which judicious arrangement in the first instance would have avoided; nor are many of our leading architects free from forgetfulness in this respect.

"Another and a very important object to be seen in Methodist chapels, and which was carefully and anxiously considered by the committee, was *the furnishing of seat-room for the children of Sabbath and Week-day Schools.*

"A farther important subject, which engaged the serious deliberations of the committee, was *seat-accommodation for the Adult Poor.*

"There is another subject which demands the serious consideration of Ministers and Trustees who may engage in chapel building; and that is, *the evil*, as I regard it, *of erecting very large Methodist Chapels.* It may be found expedient to have one large chapel in the central part of a populous city or town,—to be used on general occasions, such as the District Missionary Anniversary; but, to erect several such chapels in one town, is likely to retard the progress of Methodism, rather than to promote it. If two moderately-sized chapels were built instead of one of great dimensions, each containing, say, a thousand, or twelve hundred persons, of course, two Ministers would be required for their supply, instead of one, as in the case of the very large chapel. And who, that considers all the circumstances to be taken into account on this subject, will not say, that a thousand or twelve hundred persons are quite as many as should usually be assembled together for worship in one building?

"And if chapels of moderate dimensions be built, it will be found that the present plan of raising very *deep and heavy galleries* within them is neither necessary nor expedient. The introduction of galleries into buildings for divine worship is comparatively recent; and was resorted to rather in the way of a temporary convenience, than as a principle to be continued and permanently carried out. Perhaps congregations rapidly increased, as did the congregation at Kidderminster, under zealous Richard Baxter, who had not less than five galleries in his church, and some of them most grotesque in their forms. To place the greater portion of the congregation in the gallery, is like putting the pyramid to stand on its apex, rather than on its base; and is as contrary to the right order of things, as seating some five hundred persons in a gallery *behind* the minister. It is better, where circumstances will allow it, to have no side galleries. There may be an end gallery, without much interference with convenience or order; and, if the congregation should much increase, and that quickly, side galleries might *then* be added, and thus enlarged accommodation be readily made, and at a comparatively small expense. But it is better for the Minister, who, if not surrounded by galleries, can nearly see all his congregation at one view;—it is better for the worshippers, who shall have their faces all turned one way, and that towards the minister, rather than be looking at each other from opposite sides of the chapel;—it is better for the whole congregation (for it is next to impossible to ventilate thoroughly a chapel choked up with huge galleries) to have but a moderate number of sittings in the upper part of the building. And, where sufficient ground can be obtained at a reasonable price, it will not be found much more expensive to build a chapel with a larger area, and which, having no ponderous galleries to support all round its interior, may be comparatively low in its walls, and light in its materials. Indeed, the best practical men that I have conversed with on this subject have declared that, under ordinary circumstances, they would undertake to erect a chapel to accommodate a thousand or twelve hundred persons *on the ground-floor*, for as little expense as they could build one that would accommodate the same number, having galleries on three or four of its sides. I am not urging the entire exclusion of galleries, but the *moderate* use of them; and would say, let the gallery that may be put up look as if it were built for the chapel, and not the chapel appear as if it were built for the gallery.

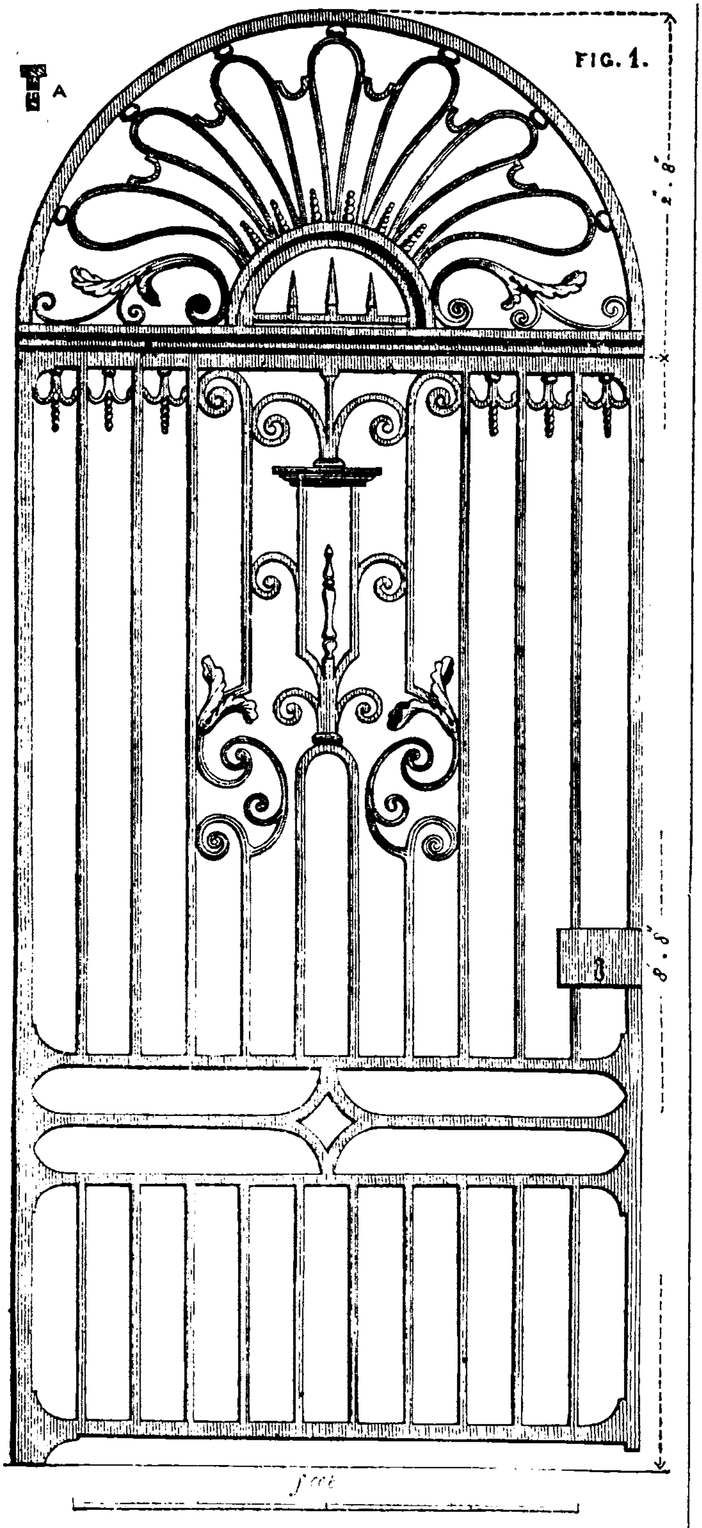
"*There should be no aisle down the middle of the chapel*, but seats: it being much better for the preacher to look directly upon his hearers, than upon an open space.

"*There should be no gallery behind the pulpit;* lest the Minister should be annoyed by the shuffling of tune-books; or the worshippers should be disturbed in their devotions by the movements in the orchestra."

The question of galleries is one which frequently comes under the consideration of architects; and, therefore, we have been induced to extract from the work on this subject at greater length than we otherwise should have done, because it gives the opinion of a man who may be considered, in a double capacity, as a practical authority.

Mr. Patric Park is fond of bold undertakings, and the one we now notice is bold and novel. It seems a gigantic model of his proposed statue to Wallace is to be erected at Glasgow, on the area near Burns's Monument, for exhibition. The proceeds are to form the nucleus of a fund for the erection of a national monument to the hero, to be placed in an important situation in the city, hereafter to be decided on. The intended monument will stand fifteen feet high without its pedestal, and the model has consumed nearly twelve tons of clay, every pound of which the artist himself carried to the spot upon his own shoulders. We think this a very good and legitimate proceeding, and we trust Mr. Park will be successful in his endeavours.

SPECIMENS OF ORNAMENTAL IRONWORK.



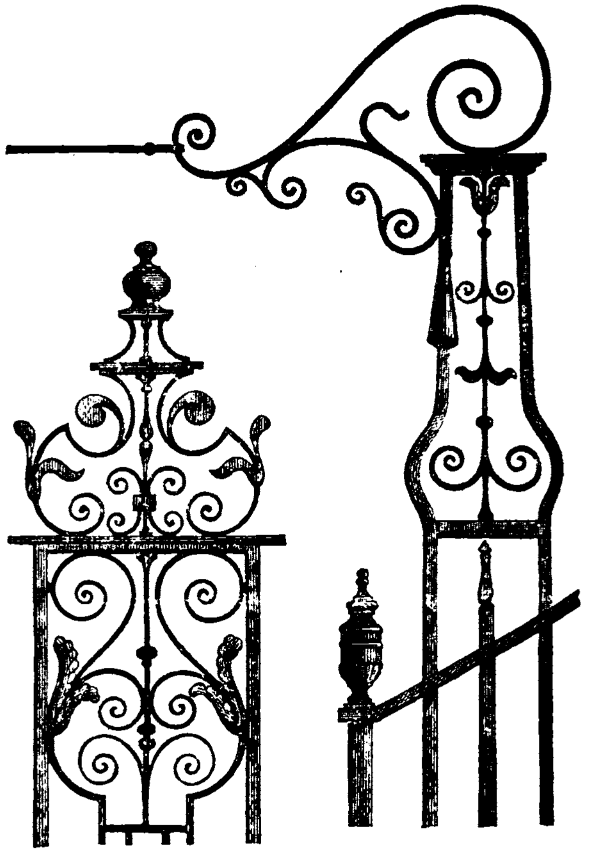


Fig. 2. Fig. 3.

It is singular sometimes to notice the influence of one form of improvement in superseding others; and little do we think, when contemplating and applauding progress, that we are likewise witnessing the first seeds of decay. There is, indeed, in things human, nothing without its alloy of evil; and we ought, therefore, always to be on our guard in all cases of innovation, lest we may, by adopting one new and good thing, destroy a still greater amount. In architectural matters this caution is particularly necessary, for the balance often is so very delicately held that the least change disturbs it. The consequence is, we have frequently, in our technical history, to notice the gradual decay of old processes in consequence of the extension of others. Thus, internal decoration has greatly suffered by the facility of moulding and reproduction; and wood carving, and ornamental ceiling work, are superseded by the repetition of composition and plaster patterns. Thus, at length we are obliged to regret we can no longer achieve, except with difficulty, the ornamental interiors of the Elizabethan or Jacobean period. In metal-work the same evil is felt. So long as the smith hammered out the details, a separate design was made for each work; but now that casting has become easy, and cast-iron cheap, design is virtually extinct in forged metal-work, and we are compelled to witness the rudest and most monotonous extensions of rails and spikes. The height of mischief once reached, regret is felt, and a strong desire evinced, if not to retrace our steps by giving up the cheaper material, at any rate to get back to good design. In the furtherance of this, nothing can be more useful than reference to good examples of the olden time; and we have therefore thought it worth while to give publicity to the accompanying sketches.

It will be noticed as the more strange that the decline has taken place when we have greater resources at our command, for the latent capabilities of iron were little imagined previous to the introduction of steam-engines, railroads, and machinery. Indeed, what would the artisans of a century and a-half ago say, could they behold the multiplied forms in which modern ingenuity has turned it to account? Now it is viewed as a valuable constructive material, of whose application every day furnishes fresh proof; then it was more usually a medium in which the cunning workman delighted to display his art, by fashioning it into those slender and graceful forms most generally adorning the lofty gates and railings of public buidings of that date.

Not a few of these tasteful specimens meet the eye of the inquirer as he lingers among the antiquated squares and once famous bye-streets of the metropolis or its vicinity; and we

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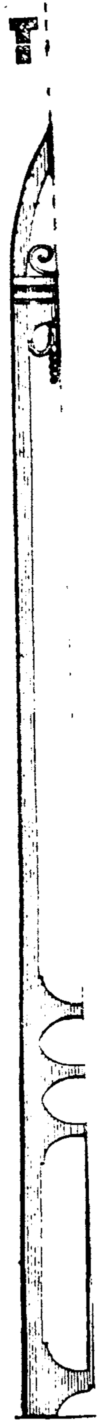

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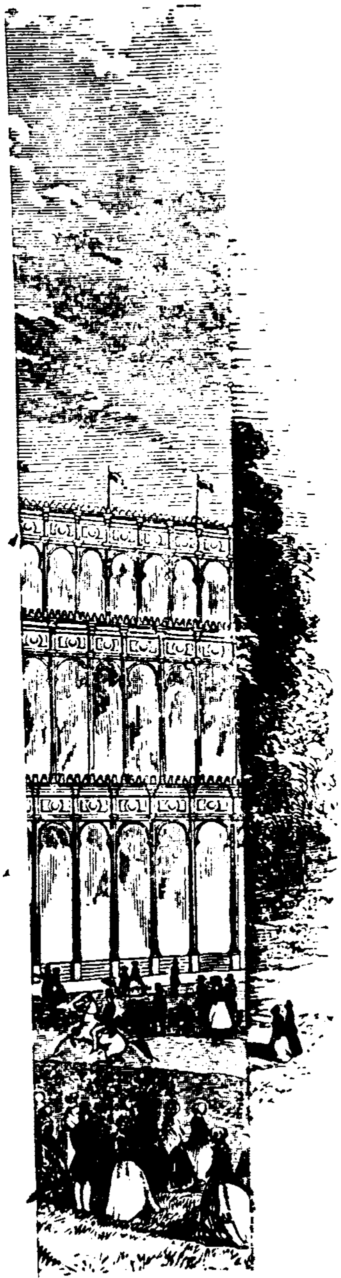


GREAT

do well to note their existence before the rage for novelty and the march of innovation have sacrificed them, like many of the edifices to which they were attached. Those which we give are as follows:—

Fig. 1, is one of the beautiful gates in the side portals to Inigo Jones's Church of St. Paul, Covent Garden. The design of this is easy and flowing.

Fig. 2, from the railing to a house in Great Ormond-street, Bloomsbury.

Fig. 3, a lamp-iron and link-extinguisher (mementoes of former customs) in Queen-square, Bloomsbury.

While we are upon this subject, we must express a further regret, and that is with regard to the retrogradation in the colouring of metal-work. Those who notice the beautiful gates of Holland Park, cannot fail to be struck with the successful application of painting and gilding in the decoration. These are made to harmonise well in the designs, and it should always be borne in mind in examining, copying, or applying old designs, that many of the thick parts are reduced by the application of light colours, and many of the slender parts are brightened by gilding. Now, one hue of black paint covers the metal surface; and, under some plea or another, gilding is abandoned altogether in exterior metal work, although the golden gallery of St. Paul's, the spires of our city churches, and the gates of Holland Park, show that it will stand well in our climate. Those who see the skilful and tasteful employment of gilding in the lampworks, railings, and gatework of Paris, always make an unfavourable comparison with London; and regret we are so neglectful of such resources. The railing of Mr. Hope's house in Piccadilly is a fine specimen of design and workmanship; but, for want of colour and gilding, it has an unfinished appearance.

THE EXHIBITION BUILDING.

(*With an Engraving, Plate* X.)

THE roof of the building is rising above the ground, and fear for its well-ending is no longer felt: but another and a weightier task is hardly begun. We have called together the world; we have found room for all that may be brought; but we have yet to make ready what we ourselves may send. In making this call, we knew it was to those skilful and proud of their skill, and by them it has been answered. From France come twelve hundred, of whom one-third have already earned rewards at home. These are the cunning craftsmen who meet us with their wares at the ends of the earth. From the Prussian Rhineland alone two hundred and fifty come; from Switzerland three hundred—men who understand cheapness as well as ourselves, and who have sometimes overcome us on our own ground. It is to be hoped in the struggle now forthcoming, and before the eyes of the world, we may not be beaten, but we must not heedlessly rush on. Here, too, it must be borne in mind, there is a greater stake than that of the Commissioners, and that we must not look to the latter alone as answerable; and the rather as we have had good warning, they cannot be very heavily burthened. The fair name of England is at stake, and unless all put their shoulders to the wheel it may not be made good. To lean upon the Commissioners, and those under them, would be weakness, when it is ourselves to whom we must look.

The Royal Commission is set forth with great men; the local committees are not named by the working men but by the givers of money; and the local commissioners are named from the local committees. Thus there is a rooted evil; for what may be a very good body for getting money together, may be the very worst for the other work, of getting together the best things. Many held back from giving money who must be asked to send their goods, and they will not hold the gift of a pound or two as a worthier right than that they hold from the gifts of mind. This is the evil now working, and, unless timely help be given, the hoped-for end will not be reached. Abroad no bickerings of this kind can arise; they are older hands at this business, and better understand their work, and so we are threatened in the coming struggle in a two-fold way, by the skill of our foemen, and by their knowledge how to make the best of it.

From the shape of these Commissions and Committees another evil threatens to arise, and which shows itself in what they have as yet set forth, which is, that they will bring together a show of knick-knacks, and a gathering of what is old, common, and worn out, rather than what being new, skilful, and workmanlike, will best show our right to the great share we hold in the trade of the world. The whole business seems too much in the hands of bookmen, and of enlightened lords, colonels, and bankers, and too little in those of men having sound and working knowledge. This we feared from the first, and we are sorry we have been found aright, for this very thing stands more than anything in the way of the whole undertaking. Lords may smile, bankers may put down hundreds, but we shall make a sorry show of it, if we trust to them to set forth our mills and our workshops, to watch over the loom, or to seek out the lowly abodes of the earnest workmen, by whom so much of our trade is fostered and carried on.

We want neither a Conservatoire des Arts et Métiers, nor a Polytechnic Exhibition; we need not trust to knick-knacks, nor to out-of-the-way trumpery, to crowd the walls and fill the stands of the building, and awaken the wonder of the sight-seers; for there will be enough, and in good keeping with the greatness of the time, and of the building. There will be steam and water setting to work the several shapes in which man's skill has brought stiffened rods of brass and iron to weave more deftly than hands of living flesh—mighty bulks which work without thought better than thought can shape—elfins which work the behest of man, and cannot withstand his will. What the wildest thought has dreamed of in earlier days as beyond the reach of man will here be brought in wondrous fulness before our eyes.

What the *Times* says on this head is so striking, that we have thought it right to give at length.

"Not the least wonderful part (says the *Times*) of the Exhibition which is to be opened next year will be the edifice within which the specimens of the industry of all nations are to be collected. Its magnitude, the celerity with which it is to be constructed, and the materials of which it is to be composed, all combine to insure for it a large share of that attention which the Exhibition is likely to attract, and to render its progress a matter of great public interest. A building designed to cover 753,984 superficial feet, and to have an exhibiting surface of about 21 acres, to be roofed-in and handed over to the Commissioners within little more than three months from its commencement, to be constructed almost entirely of glass and iron, the most fragile and the strongest of working materials, to combine the lightness of a conservatory with the stability of our most permanent structures—such a building will naturally excite much curiosity as to the mode in which the works connected with it are conducted, and the advances which are made towards its completion. Enchanted palaces that grow up in a night are confined to fairy land, and in this material world of ours the labours of the bricklayer and the carpenter are notoriously never-ending. It took 300 years to build St. Peter's at Rome, and 30 to complete our own St. Paul's. The New Palace of Westminster has already been 15 years in hand, and is still unfinished. We run up houses, it is true, quickly enough in this country, but if there be a touch of magic in the time occupied, there is none in the appearance of so much stucco and brickwork as our streets exhibit. Something very different from this is promised for the great edifice in Hyde-park. Not only is it to rise with extraordinary rapidity, but in every other respect is to be suggestive of *Arabian Nights'* remembrances. In its favour the window law is to be ignored, and 900,000 superficial feet of glass, weighing upwards of 400 tons, are to be used in its construction. Not a stone nor a brick will be employed throughout the spacious structure, which is to rest upon 3300 cast-iron columns, and to be strengthened and kept together by 2224 girders of the same material. The view of it which we now publish represents an edifice in every respect qualified to become the repository of specimens of the world's industry; the basement and two upper tiers diminishing in area as they ascend, and thus securing a graceful variety of outline, while the monotonous effect of a façade 1848 feet long is broken by a spacious transept. This transept, 408 feet long and 72 feet wide, will be arched, and will rise to the height of 108 feet, inclosing within it, as in a glass case, a row of trees, which respect for the park timber has induced the commissioners to spare. The roof of the entire building, resting on the cast-iron girders, will be what is technically called "ridge and valley," and will look like an undulating sea, the whole being covered with canvas to exclude the rays of the summer sun and prevent any inconvenience arising from excessive heat. This will be the case in every part of the structure except the transept, where the presence of trees render light necessary, and where, therefore, the arched glass roof will remain uncovered. When closed in and completed, the view presented by the interior will, it is anticipated, be wonderfully graceful and splendid. The central avenue, 1848 feet long, 72 feet broad, and 66 feet high, with rows of pillars shooting off from it on either side, and so arranged that the eye can traverse freely to every part of the building, must have a very grand appearance. Care has been taken to have the columns upon which the whole fabric rests distributed with such regularity that no confusion or forest-like effect can be produced by them. It will be the same in all the avenues as in the central one, although there, from its proportions and the entire absence of galleries or upper flooring to break the perspective, the view presented will be most imposing.

Besides the immense space thus devoted to the general purposes of the Exhibition, there will be on the north side of the building a room set apart for the reception of machinery. The dimensions of this apartment are on a scale proportionate to the important branch of inventive industry to which it is to be dedicated. It will be 946 feet long, 48 feet broad, and 24 feet high. Another feature of the building will be the Refreshment Courts, which, in accordance with the aristocratic spirit of the country, are to be divided into three classes. Those whose means and tastes incline them to patronise the first will discuss the delicacies of the season under the branches of the trees which occupy the north end of the transept; those whose habits of life are less ambitious, or whose palates are less discriminating, must move westward; while for the crowd of humble visitors the requisite accommodation will be provided on the north-east side of the building.

To enter into further details with reference to the interior plan would needlessly complicate this description, and would be inappropriate at present. It may, however, be right to mention that while from north to south and across the breadth of the structure the flooring will be perfectly level, from west to east it will be slightly inclined, like the stage of a theatre, though not of course to the same extent. This, it is believed, will add much to the effect of the interior, by enabling visitors at the lower end to see almost at a glance over the whole edifice. Though from north to south the flooring will be quite horizontal, the land slopes a little, and this enables the architect to give the building on that side the appearance of a raised foundation, which will be faced with green sod. The advantage of this to the external beauty of the principal façade it is almost unnecessary to point out. A light iron railing will inclose the building at a distance of 8 feet from its exterior, and beyond that will be a footpath. The grand entrance will be nearly opposite the Prince's gateway, and will have seven pairs of doors. Ample arrangements have been made, however, for the entry and exit of visitors at other points. The exterior surfaces of the first or ground tier will not be of glass, but of wood, for the purpose of greater security, and also to afford a wall space for such articles as require to be hung up in order to be seen to advantage. To enumerate in detail all that this great undertaking embraces would be an endless and perhaps rather a tedious task, but some conception of the work to be performed may be gathered from this—that the calculations of Messrs. Fox, Henderson, and Co., the contractors, estimate, among other requisites, 34 miles of gutters, 202 miles of sash bars, and 8 miles of table for exhibiting.

Turning from the building as it is to be to what has already been performed, it will be found that considerable progress has been made. It is now a month exactly since the actual work of construction commenced. In that time the foundation pieces on which the columns rest have nearly all been fixed upon their beds of concrete, and the earth filled in around them. The columns required for a large section of the southern and central parts of the building have been put up and connected together by girders. The framework begins to indicate the form of the future structure, just as the ribs and bones of the mammoth at the British Museum shadow forth what the animal must have been when alive. The graduated outlines of the structure ascending tier above tier, the cathedral-like effect of the transept, and the long-extended avenues and rows of slender pillars, branching off symmetrically on either side of them, can already be discerned. Sleepers and joists for the flooring have been laid in one or two parts, and one small piece of window framing has been fixed in its place. The external facing of the ground tier has been commenced, and while the framework of about one-third of the structure is in a forward state nearly every detail of the work has been begun. Messrs. Fox and Henderson have already one small crane established on the girders for hoisting up materials, and in a few days they will have several more. The rapidity with which the building progresses may be estimated from the fact, that two columns and three girders can be fixed in about 15 minutes. While the actual labour of construction proceeds, a vast amount of preparatory work goes on simultaneously. Nearly all the wooden arches required to span the transept are completed. Sash bars, window frames, intermediate bearers and gutters, are got ready by hundreds of workmen under sheds, formed hastily of floor planking. The hydraulic press is at work testing the strength of girders, and a few fires are lighted to prepare the wrought-iron bolts by which the columns are made fast to the connecting pieces between them. Piles of materials of every kind are collected in every part of the ground, and it is believed that three-fourths of all that will be required are already deposited within the hoarding. There is a stable for 20 horses, which are employed in drawing. At present 900 hands are at work within the inclosed space, but it is estimated that the number must yet be raised to 1500. No difficulty is found by the contractors in procuring the requisite supplies either of material or labour. The iron work is all brought from Birmingham, where it is prepared by Messrs. Fox and Henderson, assisted by two other houses. One firm furnishes the whole amount of glass required. The timber used is from the Baltic, and of excellent quality. A portion of it is prepared at mills taken for the purpose at Chelsea, and the rest on the grounds. When the weather is wet, this part of the work, which is carried on under cover, is pushed forward. When it is dry the fixing of columns and girders is proceeded with. Gas has been laid on in the grounds, and the toils of the day are continued frequently as late as 11 o'clock at night. Within a commodious set of offices the heads of departments regulate the work and prescribe the division of labour to be pursued. Here, too, a room has been established for draughting plans of the building, in conformity with which it is to be completed. A considerable portion of the work is done by the *piece*, and no difficulty is found in procuring any amount of hands that may from time to time be required. Every morning they assemble in great numbers at the entrance ready for employment, and when engaged they turn out very efficient workmen. Such a supply must be regarded as one of the most important facilities which a great city like London presents for the execution of an undertaking like this. An ingenious system of checks by means of variously shaped brass tokens has been introduced to determine the number of hours per day for which each man has been occupied, and the remuneration to which he is entitled. The whole business of the contractors seems to be carried on the most systematic and orderly manner; and what is very remarkable is the little noise or bustle with which the work proceeds. When the materials of which the building are chiefly composed are recollected this will be the more easily understood. Nearly everything is brought on the ground ready to be put up, and the loudest sound that reaches the ear is the occasional clink of a hammer 'closing rivets up.' Over so large a space the noise of labour is lost, and the building ries almost as silently as did Solomon's temple.

The contractors still speak with perfect confidence of their ability to construct and roof-in the whole before New Year's-day. They have within the last month done a good deal, but in the two that still remain to them they will find their energies fully taxed to do all that still remains to be accomplished. If within the limits of time prescribed to them they succeed in carrying out so extensive and elaborate a plan as that which they at present contemplate, they will merit the utmost praise; but before even the letter of their contract the safety of the public must be placed, and we do trust that every precaution will be adopted to prevent the possibility of accidents hereafter. Of late years many circumstances have occurred to shake the confidence which was at first reposed in iron structures. Suspension bridges and railway termini have been giving way and falling in from comparatively slight causes—the smallest defect in a part, the snapping of a rod, or the shaking of a pillar, by disturbing the distribution of forces, often brings down the whole fabric. The new building in Hyde-park is a novelty in architecture—and a novelty upon a grand scale. It is to be provided with many galleries, where specimens of industry will be exhibited, and where, therefore, crowds of visitors will assemble to inspect. Considering the materials used, therefore, it is most important that every care should be taken to insure the safety of these galleries. Messrs. Fox and Henderson say that they have adopted every precaution in this respect, and that their calculations of strength are such as to render an accident from the crowding of spectators impossible. We trust that it may be so, and we think it due to them to state that a minute examination of the progress already made in the work has impressed us with a high sense of the efficient, orderly, and expeditious manner in which it is carried on. This is the more remarkable when the novel character of the structure is remembered, that novelty removing it out of the routine habits of those engaged in the labour of construction."

IMPROVEMENTS OF THE RIVER SEINE.

Some very important works are in progress at present upon the river Seine, for the improvement of the navigation of that river, a succinct account of which is appended.

The Seine has a very long devious course, principally through a valley in the tertiary limestones of the Paris basin, and through the chalk between Mantes and the sea. It is very subject to floods in the winter and spring, which come down from the hills of Burgundy with considerable violence; whilst in the summer it is often so low that, as in 1842, the navigation by barges drawing 4 feet water is suspended. The tide runs to a little beyond Pont de l'Arche, a distance of perhaps 60 miles.

Owing to the configuration of the embouchure a bar is formed at Quillebœuf and Tancarville, at a point where the river—which had previously spread out on both sides over a flat alluvial plain, sometimes bare at high tides—is contracted between two advancing spurs of the chalk formation. Formerly the regime thus superinduced was such as to give rise to a "bore" of about 3 to 4 feet high occasionally; but at neap tides there was never enough water on the bar to allow a 400 tons' burden ship to mount the river, although directly the stream became narrowed above Villequier, sufficient depth to float even a 1000 ton ship existed at high tides.

The objects proposed then were to deepen the river so as to allow large vessels to reach Rouen, and to establish such a system of locks, &c. in the upper portion, as to ensure a constant depth of 6 ft. 6 in. in the driest seasons as far as Paris. The works already executed have succeeded most remarkably in the attainment of these objects as far as they bore upon them. They are as follows:—

Tidal Portion.—Up to August, 1850, they had been confined to the embankment of the river between Candebec to Villequier and Quillebœuf, by means of rubble-stone embankments of a length of 18,000 mètres on the right bank, and of 9600 on the left bank. At the point where the works commenced the channel was made 300 mètres (1000 feet) wide; and it was augmented 10 mètres in a kilomètre, or in the ratio 1 : 100 to the embouchure. The concave embankment was found to require twice as much stone as that upon the convex side, the former taking 100 mètres cube, the latter 50 mètres cube, per mètre forward.

The result has been to deepen the river 2·80 mètres (a little more than 9 feet). The "bore" has disappeared in the parts regularised; the length of the duration of the flood tide increased one hour; the still water, or dead tide, has also gained a quarter of an hour. The flood would be sent much further up the country did not the stone thrown to protect the feet of the piers of the Manoir Bridge, on the Rouen and Paris Railway, act as a dam to keep it back. It is probable that the result of the works in the river upon this bridge will be to throw it down.

The total cost of the embankments has been hitherto 2,310,000 francs, or 92,400*l.* sterling, being at the rate of 3 francs the mètre cube of stone in place.

To complete the project, it would be necessary to execute above Candebec and la Meilleraie 5,122 mètres of embankment on the right, and 8,700 upon the left shore. Below Quillebœuf it is proposed to continue the channel through the sandbanks of the embouchure, by the execution of 12,540 mètres on the right bank, and 9600 upon the left.

Natural Water Course above Tides.—The system adopted for the attainment of the depth required in this portion, has been to erect a series of barrages or weirs upon the river, so as to divert the water into the arm rendered navigable, and to leave an overflow under the control of the locksman at the head of the pond or reach.

The weirs are formed according to the plan so successfully applied by M. Poirée at Bezons, consisting of a series of wrought-iron frames with wooden blades to close the openings, fixed by hand; the wing walls are in stone, and dressed off at a level to allow any flood-water to overflow at 6 inches above the depth required in the lock, should any sudden flood come down by night. The locks are made 120 mètres long by 12 mètres wide (400 feet by 40 feet), and a fall of 2 mètres, or 6 ft. 7 in. nearly.

Originally it was proposed to form at least ten of these barrages. The first is formed in Paris itself, and is actually in course of execution; the river is being inclosed to a width of 32 mètres in the narrowest part, beginning from the extremity of the Isle de la Cité, and terminating at the extremity of "terre Plein" of the Pont Neuf. The wing walls of the dam are dressed off at a height to secure 2·16 mètres water; the barrage is meant to heap them up to 2·26 mètres; but of course before arriving at this height, some of the blades would be drawn. Quay walls and roads, with inclined approaches from the upper level, are being formed; a large culvert, 2·50 mètres wide by 2·50 mètres from invert to key, is also constructed to take off the lateral sewers to a level below the locks. These works are estimated to cost 200,000*l.* sterling.

Connected with these works may be cited the lowering of the roadway of the Pont Neuf, to cost 72,000*l.* The old arches are cut away where necessary, and replaced by new arches of an elliptical form, the space between the new and old work, where any exists, being filled-in with hydraulic lime concrete. The scaffolding employed is very remarkable, being in fact a suspension scaffolding, hanging from the turrets on the piers of the bridge. Indeed, it would be impossible to imagine how works could be so carefully, so perfectly, and so elaborately executed, as all these are, unless by French engineers, working with government money.

Other barrages have been executed at Bezons, Andrésy, and Vernon; one at les Poses, near Pont de l'Arche, is in course of execution. Barrages are to be formed immediately at St. Ouen Meulan; others are proposed at Suresnes, Maisons, Triel, and perhaps others below Meulan.

The barrage executed at Bezons, at a cost of 80,000*l.*, gave a sur-elevation of 1·20 mètres (4 feet) at a distance of 7½ miles from the locks, the fall of the river being on the average 0·10 per kilometre, or 1 in 10,000. The heaping-up of the waters by the barrage of Andrésy is felt in the Seine and Oise, at a distance of 20 kilometres, or 12½ miles.

At some future day I will send you drawings of the barrage of Bezons, which will illustrate the very simple, but efficient means employed on this river, to canalise it completely.

Geo. R. Burnell.

Southampton, Oct. 23rd, 1850.

PUBLIC WORKS AT ALGERIA.

The East India Company have at length roused themselves from the state of inaction they so long preserved in the execution of railways and other communications in their immense possession. It is better late than never. But to enable your readers to compare the conduct of a government managed under the direct control of a representative assembly, with that of the anomalous body known in India as the Coompanni Jehan, I have the honour to inclose you a condensed statement of what has been done by the French government in Algeria since their occupation in 1830.

It is to be observed, that we are far from wishing to hold up the colonial government of our neighbours as a model in all things; but the care they have taken in the execution of means of communication between the different points of their still very precarious possession, may well merit our serious consideration.

In the report from the Minister of War to the Legislative Assembly, in the spring of 1850, it is stated that, subsequently to the occupation of Algeria, there have been executed in that colony, at the expense of the mother country, no less than 3270 miles of road; 18,959 acres of marsh lands have been drained; 278,000 yards linear of irrigation channels; and 82,057 yards of main drains or ditches; and 127,000 yards of aqueducts or water courses have been constructed; 91,900 yards linear of street have been formed or regularised in the divers towns; and nearly 32,000 yards linear of sewers formed in them; barracks have been erected for 40,000 soldiers, and hospitals for 5000 invalids. The port of Algiers has been improved, and important works begun at several other points on the coast. Churches for the Christian population, mosques for the indigenous races, have been restored, and new ones built where needed.

The country in which these works have been executed is only 77,120,000 acres superficial (France itself being 131,966,525 acres nearly), including the Little Desert, which occupies above two-thirds of the surface. The densely-peopled portions are the civil territories of the Prefectures of Algiers, Oran, and Constantine, whose total surfaces are only 706,902 acres. The population in 1848 consisted of 64,123 Frenchmen, 55,141 other Europeans, mostly Maltese, Spaniards, and Sicilians. The different sexes and ages are—men, 49.839; women, 34,937; children, 34,488. The indigenous population is supposed to be three millions; and the army of occupation 60,000 men.

Has our occupation of India produced equal advantages to the native tribes? Have we done so much to assist their advance in civilisation? If not, have we not rather abused our strength than fulfilled the duty our superior intellectual position imposes on us; and shall we not suffer the penalty sooner or later? A foreign nation never can retain possession of another country, unless it secure to its subjects a greater amount of happiness and prosperity than it could procure itself. Doubtlessly, the native kings of India did less for their subjects than the Company has done; but the example of the French government would lead us to question whether we have fulfilled our whole duty. There are in India far less artificial means of communication than there are in Algeria. Yet what are the relative populations, surfaces and especially, what are the revenues obtained in the respective cases? For it is to be observed, that Algeria has cost France at least four millions sterling per annum for the last 20 years, whilst India yields a large sum to be divided amongst the share or bondholders every year.

Geo. R. Burnell.

Southampton, Oct. 23rd, 1850.

VENTILATING APPARATUS.

In No. 152 of the *Journal* (p. 145), we pointed out the efficient internal arrangements of the York County Lunatic Asylum, of which we gave the plans and elevation. Among these arrangements, which we could not then particularly describe, is the ventilating apparatus, which was exhibited to several architects and men of science at the warehouse of Messrs. Baily, ironmongers, High Holborn. This apparatus is constructed under the directions of Dr. Arnot, and was explained by him to Lord Wriothesley, Sir Thomas Deane, Dr. Ure, Professor Donaldson, Mr. Fowler, Mr. Godwin, Mr. Laxton, and some other gentlemen. Those who know the enlightened, energetic, and disinterested efforts of Dr. Arnot for the extension of mechanical appliances in aid of hygienic science, will not fail to receive with pleasure this new application of his ingenuity. The water-bed, much as it may be justly esteemed by medical men, is no less an admirable exemplification of mechanical skill in the adaptation of simple means. The apparatus which we are now about to describe, is likewise very simple, and at the same time promises to be very effective.

The apparatus is shown in the annexed engravings, of which fig. 1 is a plan and fig. 2 a section, taken through the centre from A to B. It consists of a fixed cylinder, placed in the centre of a room, and which cylinder is about 5 ft. 6 in. diameter and 5 ft. high; with a chamber above and below, each furnished with inlet-valves to receive the air from the fresh-air shaft, and outlet-valves to deliver the air into the adjacent chamber, and thence distributed through the building. The cylinder is made of galvanised iron, is open at both ends, and has an outer case at about 3 inches distance, and the whole depth of the cylinder filled with water, which forms an annular hydraulic joint. Within this cylinder is another cylinder, 5 ft. 9 in. diameter, inclosed on the top, similar to the rising bell of a gas-holder; the rim of this cylinder works up and down in the water contained in the annular rim just described. By this arrangement the communication with the upper and lower compartments is cut off.

The working cylinder is suspended to the end of a moveable beam about 10 feet long, and balanced by a weight or bob suspended to the other end, equal in weight to the moveable bell, minus a sufficient weight to cause the bell to descend and expel the air in the lower compartment. Now, for the purpose of setting the beam in motion, it is necessary to have some moveable power to overcome the friction of the moveable parts and the air. For this purpose Dr. Arnot has adopted a single-action water-engine, having a cylinder 2 inches diameter and 12 inches stroke; to be supplied by water from a reservoir placed on the top of the building, 60 feet above the engine. A column of water of this altitude acts with a pressure of about 30 lb. on every moveable square inch of the piston; and if the piston be 2 inches diameter, it will be equal in round numbers to 3 square inches, consequently the force of the water acting on the piston will be 3 × 30 = 90 lb.; and this is the power with which the Doctor proposes to work the apparatus, and as the engine is single-acting, the cylinder will require about a pint of water for every stroke. Thus, if the engine works 8 strokes per minute, it will require 8 pints of water, or 1 gallon per minute, to keep the beam moving.

This engine is placed so that the connecting-rod is connected with the moveable beam at 1 foot from the fulcrum; and if the beam have a radius of 5 feet, and the working cylinder be suspended at the end of the beam, the bell will be elevated 5 feet at every stroke of the engine. When the piston has performed one upward stroke by the pressure of the water, the water is cut off by a slide-valve, and that which is within the cylinder is discharged into an open pipe; consequently, the extra weight of the moveable parts will cause the piston to descend, and at the same time the working cylinder will also descend. Now, if we suppose that at the commencement of the working of the apparatus the working cylinder is close down on to the fixed cylinder, the upper compartment will be filled with air, and as it rises it will displace a quantity of air equal in capacity to the cubic contents of the working cylinder, and force it out of the valves that open outwards; and at the same time that the cylinder is rising, the space below is increasing equal in capacity to the cylinder, and a quantity of air rushes in through the valves opening inwards, and fills up the space; and when the bell begins to descend, the lower inlet-valves close and the lower outlet-valves open, and the air that is below is forced out through the outlet-valves of the lower compartment, and at the same time the air is being admitted into the upper compartment, as before described. By this means the action is double, and a constant stream of air is being taken in through either of the inlet-valves, and forced out through the upper or lower outlet-valves into the adjacent chamber, and thence through trunks and cases to all parts of the building.

Now, it has been shown, that for every stroke of the engine the working cylinder displaces a quantity of air equal to its capacity in both the bottom and upper compartments; and as the capacity of the working cylinder is equal to 125 cubic feet, it displaces in both compartments 250 cubic feet for every upward and downward stroke of the engine, at an expense of one pint of water, descending from an altitude of 60 feet; and if the engine works 8 strokes per minute, it will displace 2000 cubic feet of air, at an expense of 8 pints, or one gallon of water, which is equal to 2,880,000 cubic feet of air, displaced by the aid of 1440 gallons of water for 24 hours. These are the proportions proposed by Dr. Arnot for ventilating York Hospital.

For the purpose of feeding the apparatus, pure air is brought down a shaft, the top of which is considerably above the top of the building, and which communicates at the bottom with the chambers before described; and if it be desired that the air be warmed, it is effected by allowing the air, as it is expelled from the chambers, on its passage to the trunks, to pass between a series of hollow copper vessels filled with hot water.

The adaptation of the water-engine, which Dr. Arnot proposes to adopt, is particularly desirable, as it can be worked at comparatively little expense, and the water, after it has done its work in the engine, may be used for domestic purposes. It will also be seen that by this apparatus the whole of the air forced in for ventilation can be accurately measured if a counter be attached to the engine to show the number of strokes the engine has performed during the day.

Reference to Engravings.

Similar letters refer to similar parts in each figure.

A, is a fixed cylinder, open at both ends with outer case *a*, filled with water, forming an annular hydraulic joint.

B, working cylinder inclosed on the top and open at the bottom; the rim works up and down in the hydraulic joint *a*.

C, C′, upper and lower chambers, with inlet valves *iv*, opening inwards to take in the air from the external air-shaft E; and outlet valves *ov*, opening outwards to convey the air to the shaft D, and thence to the building through the trunk T.

F, furnace-room, in which is placed the boiler with four square fire-boxes *f*, *f*, *f*, *f*, to heat the water for supplying the copper cells *g*, when it is required to warm the air as it is being forced into the building; there are several of these copper heating cells placed side by side, with narrow spaces between for the air to pass through.

H, a water-engine, acted on by a column of water on one side of the piston, which is brought by a pipe *h*, from a cistern placed on the roof 60 feet above; *j*, is an air-vessel to prevent concussion by cutting off the water suddenly; *k*, gear for opening and shutting the eduction and induction valves; *l*, piston and connecting-rod.

K, balance-beam; at one end is fixed a chain to suspend the working cylinder, and at the other end is another chain to suspend a balance-weight *m*.

VENTILATING APPARATUS.

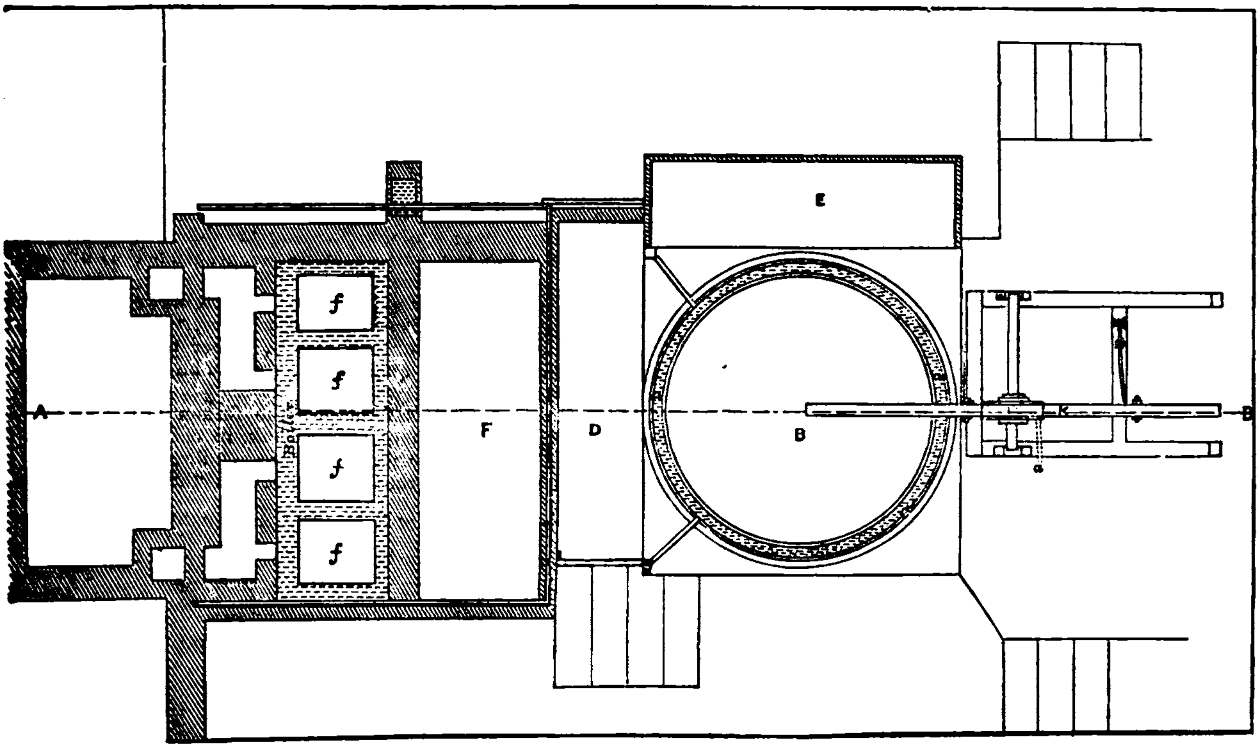


Fig. 1.—Plan.

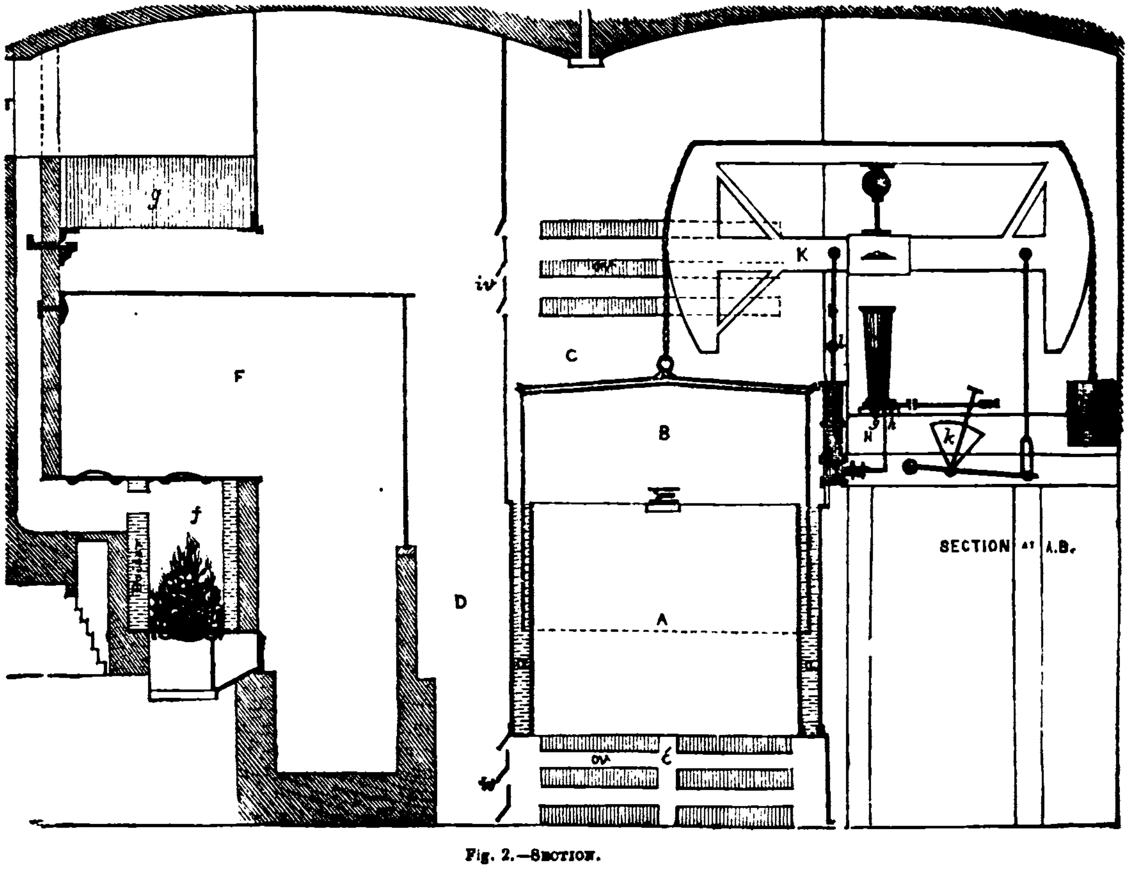


Fig. 2.—Section.

EARTHWORK CALCULATIONS.

On the Calculating of Earthwork. By James Henderson, C.E., Glasgow.

In the calculating of earthwork, where the base and slopes are regular and uniform, as in the case of railways, roads, &c., the following short table I have found both useful and expeditious:

No.'s Feet.	Centre.	Sides.	Difference.	No.'s Feet.	Centre.	Sides.	Difference.
1	2·4	2·4	·2	26	63·5	1652·4	137·7
2	4 9	9·8	·8	27	66·0	1782·0	148·5
3	7·3	22·0	1 8	28	68·4	1916·4	159 7
4	9·8	39·1	3·3	29	70·9	2055·8	171·3
5	12·2	61·1	5·1	30	73·3	2200·0	183·3
6	14 7	88·0	7·3	31	75·8	2349·1	195·8
7	17·1	119 8	10·0	32	78 2	2503 1	208·6
8	19·5	156·4	13·0	33	80 7	2662·0	221·8
9	22 0	198·0	16 5	34	83 1	2825·8	235 5
10	24 4	244·4	20·4	35	85 5	2994·4	249·5
11	26 9	295·8	24·6	36	88 0	3168·0	264·0
12	29·3	352·0	29·3	37	90·4	3345·4	278·9
13	31·8	418·1	34·4	38	92·9	3529 8	294 1
14	34 2	479·1	39·9	39	95·3	3718·0	309 8
15	36·7	550 0	45·8	40	97·8	3911·1	325 9
16	39·1	625·8	52·1	41	100·2	4109·1	342·4
17	41·5	706·4	58·9	42	102·7	4312·0	359·3
18	44·0	792·0	66 0	43	105·1	4519·8	376·6
19	46·4	882·4	73·5	44	107·5	4732·4	394·4
20	48·9	977·8	81·5	45	110·0	4950·0	412·5
21	51·3	1078·0	89·8	46	112·4	5172·4	431 0
22	53·8	1183·1	98·6	47	114 9	5399·8	450·0
23	56 2	1293·1	107·8	48	117 8	5632·0	469·3
24	58·7	1408 0	117·3	49	119 8	5869·1	489·1
25	61·1	1527·8	127·3	50	122·2	6111·1	509·3

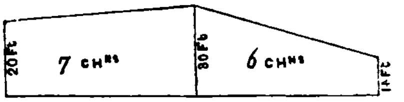
Rule. To the quantity in column of Sides, corresponding to the mean height in column of No.'s, add the quantity in column of Difference corresponding to the difference of heights in column of No.'s, and multiply the sum by the length of cut or bank in chains; and that product by the slope of banks, for the cubic yards in sides of said cut or bank.

Again, multiply the quantity in column of Centre, corresponding to the mean height in column of No.'s, by the length of the cut or bank, in chains; and that product by the breadth of base, in feet, for the cubic yards in centre of said cut or bank.

The sum of these two quantities gives the total cutting or banking, in cubic yards.

Example.

Transverse Section.



Longitudinal Section.

Lengths.	Mean and difference of heights.	Centre.	Sum of sides and difference.	Product of centre and lengths.	Product of sum of sides and d'fference into lengths.
7	25 10	61·1	1527·8 20·4 1548·2	427·7	10837·4
6	22 16	53·8	1183·1 52·1 1235·2	322·8	7411·2

750·5	18248 6
30	1½
22515 0	18248 6
	9124·3

Sides . . 27372·9
Centre . 22515·0

Total . . 49887·9 cubic yds.

The principle on which this table is based is—That the difference between the true contents of the sides of a cut or bank and the contents found by taking the mean section, varies as the square of the difference of heights; the true contents more or less exceeding the contents obtained by taking the mean section as the difference of heights is more or less. In table, the quantities in column of Sides are the contents of sides by taking the mean section, and the quantities in column of Difference those required to be added in order to obtain the true contents. In Bidder's table for calculating earthwork, the true contents of sides are given for every variation of mean and difference, which consequently causes a very large number of different quantities in table; so much so, that if, instead of being carried out every foot in height to 50 feet, it were carried out every tenth of a foot to 50 feet, it would occupy a good-sized volume; while, by keeping the difference separate, as in the above table, the same could be comprehended within a few pages, and be less complicated.

In this, as well as in Bidder's table, the contents are correct only when the ground is uniformly level transversely; but, as the surface is generally more or less sloped, it becomes important to ascertain the additional quantity required to be added in order to obtain the true contents.

Take C = contents as found by the former table; B = ½ of base in feet; L = length of cut or bank, in chains; S = slope of banks; and T = tabular number corresponding to the slope of banks and surface of ground, as given in the adjoining table. Then, $\left(C + \frac{22 . B^2 . L}{9 . S}\right) \times T =$ additional quantity required to be added to contents C, in order to obtain the true contents.

Slope of ground.	Slope of banks.	
	1½ to 1	2 to 1.
1 in 5	·0989	·1904
" 10	·0230	·0416
" 15	·0101	·0181
" 20	·0056	·0101
" 30	·0025	·0044
" 40	·0014	·0025
" 50	·0009	·0016
" 60	·0006	·0011
" 70	·0004	·0008

Example. Suppose that in the former example the average slope of the ground was 1 in 10. Then,

$$\left(49887{\cdot}9 + \frac{22 . 15^2 . 13}{9 . 1\frac{1}{2}}\right) \times {\cdot}023 = 1257 \text{ cubic yards,}$$

which, added to 49887·9, gives 51144·9 cubic yards for the true contents of cutting.

SYMMETRIC PROPORTION.

On an Application of the Laws of Numerical Harmonic Ratio to Forms generally, and particularly to that of the Human Figure. By D. R. Hay, Esq.—(Paper read at the Royal Society of Edinburgh.)

The author stated in some prefatory remarks, that a belief in the operation of the laws of numerical harmonic ratio in the constitution of beautiful forms had long existed, although those laws had not been systematised so as to render them applicable in the formative arts. In proof of this, Mr. Hay quoted a correspondence upon the subject of harmonic ratio, between Sir John Harrington and Sir Isaac Newton, in which the latter expresses his belief in such laws in the following words: "I am inclined to believe some general laws of the Creator prevailed with respect to the agreeable or unpleasing affections of all our senses; at least, the supposition does not derogate from the power or wisdom of God, and seems highly consonant to the simplicity of the macrocosm in general." The belief of this great philosopher, the author trusted, would form some apology to men of science for the repeated attempts he has made to establish the fact. These attempts he had hitherto made with reference to architecture, to ornamental design, and latterly to the human head and countenance; but on the present occasion he intended to show the operation of these laws in constituting the symmetrical beauty of the entire human figure.

He next proceeded to point out the remarkable similarity that exists in the physical constitution of the organs of hearing and seeing, and the manner in which external nature affects the sensorium through these organs; showing the difference between noises and musical sounds in the one case, and irregular and regular forms in the other. He explained that each musical sound was produced by a number of equal and regular impulses made upon the air, the frequency of which determining the pitch of the sound; their violence its loudness; and the nature of the material by which the impulses were made its quality or tone. In like manner, he showed that the effect upon the optic nerve produced by external objects is simply that of the action of light, and amenable to the same laws. Variety of form being analogous to variety of pitch; variety of size to that of intensity or loudness; and variety of colour to that of quality or tone.

Mr. Hay next explained the nature of the harmonics of sound, which result from the spontaneous division of the string of a monochord by the formation of nodes during its vibratory motion. He then showed how the harmonics of form could be evolved from the quadrant of a circle by the following process:—

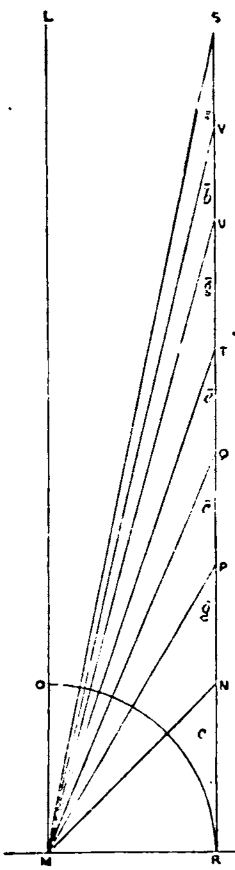


Fig. 1.

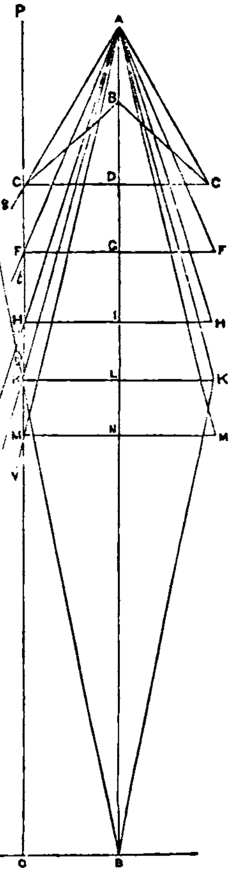


Fig. 2.

From a horizontal line MR, fig. 1, he produced two parallel vertical lines ML, and RS, indefinitely, and with a radius MR described, from the centre M, the quadrant OR. From O, he divided the arc of the quadrant into parts of $\frac{1}{8}$, $\frac{1}{7}$, $\frac{1}{6}$, $\frac{1}{5}$, $\frac{1}{4}$, $\frac{1}{3}$, and $\frac{1}{2}$. From the centre M, and through these divisions, he produced the lines MN, MP, MQ, MT, MU, MV, and MS, until they met RS, forming the right-angled triangles MPR, MQR, MTR, MUR, MVR, and MSR. He then showed, that as the angles at the vertex of each of these triangles, contained respectively 45°, 30°, 22°, 30′, 18°, 15°, 12°, 51′, 26″, 11°, 15′, they related to the right angle, as the harmonics of sound, expressed by the signs c, g, $\bar{c}$, $\bar{e}$, $\bar{g}$, $\bar{b}$, and $\bar{\bar{c}}$, relate to the fundamental note C, produced by the string of the monochord. These triangles he combined in the following manner upon a line AB, fig. 2, which he said might be of any given length according to the size of the figure to be formed. From B, at an angle of 11° 15′ with AB, he drew the line B*g*, indefinitely, and from A at an angle of 15° with AB the line A*r* also indefinitely, and cutting B*g*, in K. Through K, he drew KL at right angles with AB, forming the triangles ALK and KLB. Through K he drew the line *p*O parallel to AB. From A at an angle of 12° 51′ 26″ with AB he drew AV, cutting *p*O in M, and drew MN at right angles with AB, forming the triangle AMN. From A at an angle of 18° with AB, he drew A*u*, cutting *p*O in H, and drew HI at right angles with AB, forming the triangle AHI. From A at an angle of 22° 30′ with AB, he drew A*t*, cutting *p*O in F, and drew FG at right angles with AB, forming the triangle AFG. From A at an angle of 30° with AB he drew A*s*, cutting *p*O in C, and drew CD at right angles with AB, forming the triangle ACD. From C at an angle of 45° with AB and CD he drew CE, forming the triangle CDE. Thus, he observed, were the triangles arising from the harmonic angles constructed upon AB in the same relative proportions to each other, that they were when formed upon the line RS, fig. 1. Upon the other side of AB he constructed similar triangles forming the equilateral triangle ACC; the right-angled isosceles triangle ECC, and the acute-angled isosceles triangles AFF, AHH, AKK, AMM, and BKK. Within this diagram he showed that the human skeleton could be formed in the most perfect proportions, determining, at the same time, the centres of all the various motions of the joints; and also that the symmetrical beauty of the external form, whether in a front or profile view, was governed by these angles; thus endeavouring to prove that an application of the laws of numerical harmonic ratio in the practice of the sculptor and painter would give these imitative arts a more scientific character than they at present possess, and, so far from retarding the efforts of genius, would rather tend to facilitate and assist them.

Professor KELLAND'S *Exposition of the Views of* D. R. HAY, Esq., *on Symmetric Proportion.*

THE fundamental hypothesis of the author was stated to be this:—That the eye is capable of appreciating the exact subdivision of spaces, just as the ear is capable of appreciating the exact subdivisions of intervals of time; so that the division of space into an exact number of equal parts will affect the eye agreeably in the same way that the division of the time of vibration in music, into an exact number of equal parts, agreeably affects the ear. But the question now arises—What spaces does the eye most readily divide? It was stated that the author supposes those spaces to be angles, not lines; believing that the eye is more affected by direction than by distance. The basis of his theory, accordingly, is, that bodies are agreeable to the eye, so far as symmetry is concerned, whenever the principal angles are exact submultiples of some common fundamental angle. According to this theory we should expect to find, that spaces in which the prominent lines are horizontal and vertical lines, will be agreeable to the eye when all the principal parallelograms fulfil the condition that the diagonals make with the sides, angles which are exact submultiples of one or of a few right angles. This application of the theory was exemplified by a sketch of the new Corn Exchange erected in the Grassmarket, Edinburgh, by David Cousin, Esq., whose beautiful design was shown to have been constructed with a special reference to the fulfilment of this condition.

The author was stated to proceed to apply his theory to the construction of the human figure, in which we should expect *à priori* to find the most perfect development of symmetric beauty. Diagrams were exhibited which represent, with remarkable accuracy, the human figure; and it was explained that not a single lineal measure is employed in their construction. The line which shall represent the height of the figure being once assumed, every other line is determined by means of angles alone. For the female figure, those angles are, one-half, one-third, one-fourth, one-fifth, one-sixth, one-seventh, and one-eighth of a right-angle, and no others. It must be evident, therefore, that, admitting the supposition that the eye appreciates and approves of the equal division of the space about a point, this figure is the most perfect which can be conceived. Every line makes with every other line a good angle. The male figure was stated to be constructed upon the female figure by altering most of the angles in the proportion of 9 : 8; the proportion which the ordinary untempered flat seventh bears to the tonic.

A drawing was exhibited, which had been designed with great care from the life, by the distinguished academician, John A. Houston, Esq. On this drawing the author had constructed his diagrams; and the coincidence of theory with fact was seen to be complete. Professor Kelland argued, that a principle so simple and comprehensive in its character, and thus far apparently truthful in the conclusions to which it leads, merits, and should receive, the most complete and rigid examination.

PLATE-IRON GIRDER BRIDGES.

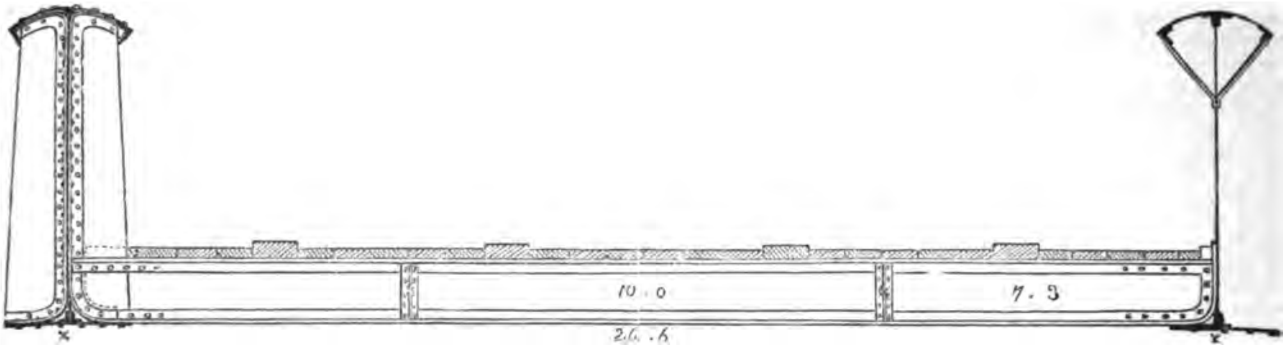


Fig. 1.—Transverse Section.

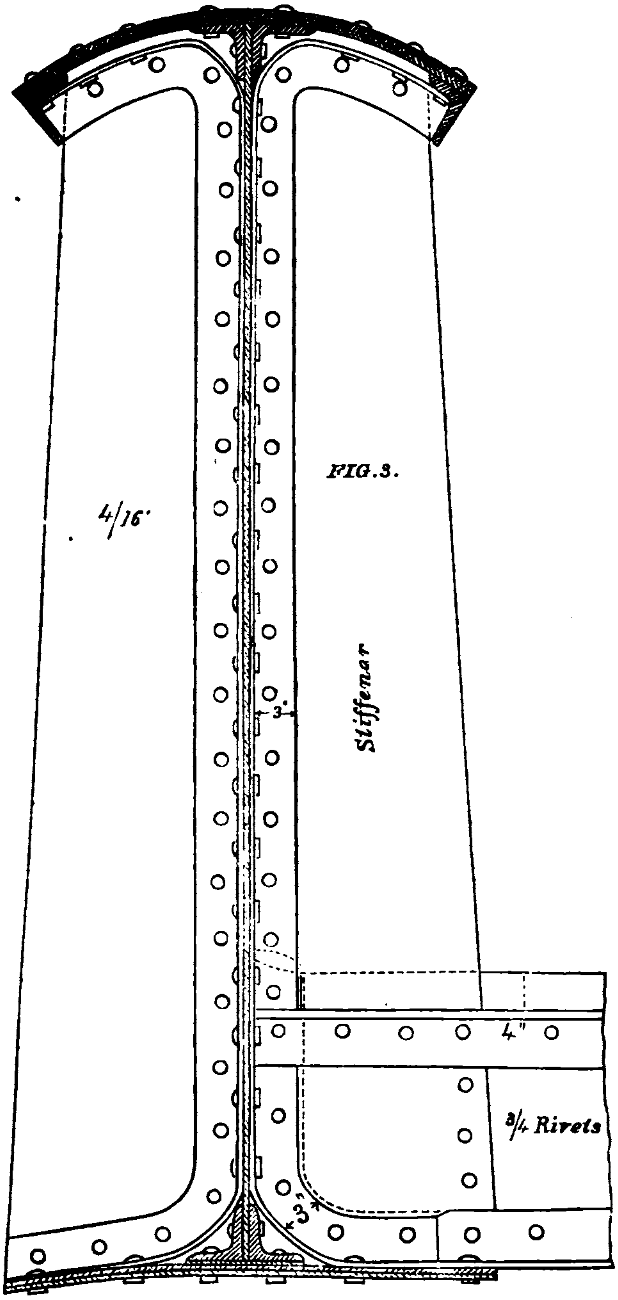


FIG. 3.

Enlarged Section of Girder, showing the Stiffeners.

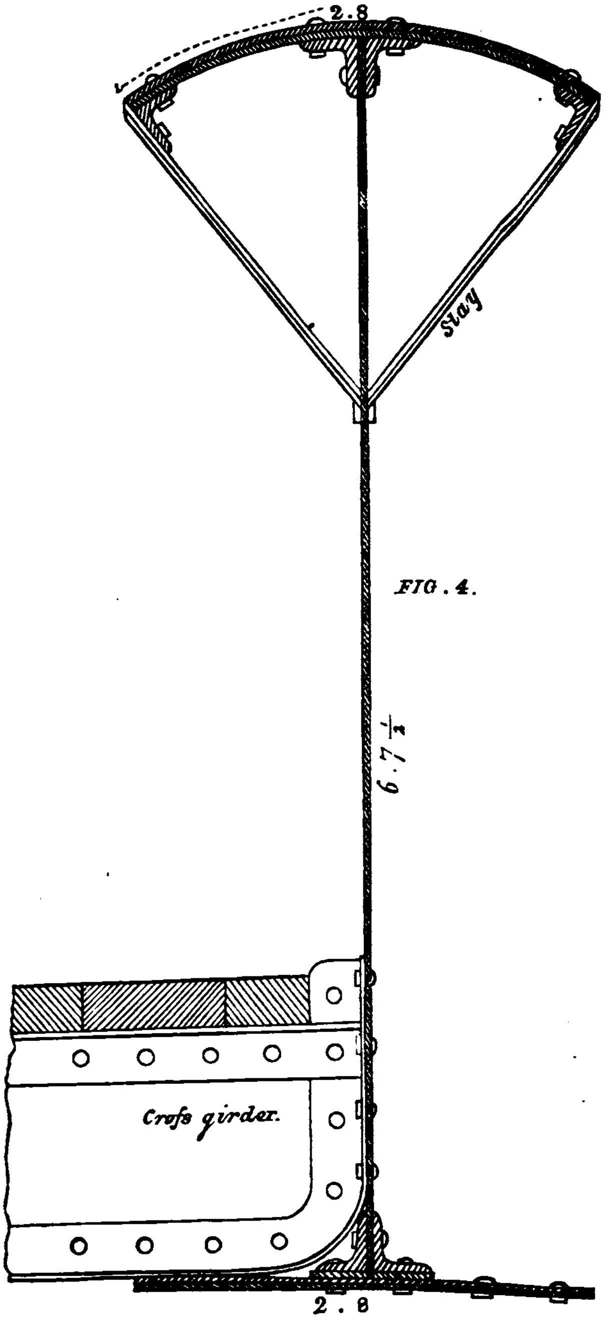


FIG. 4.

Section through Girder, showing the Stays to Stiffen the Top Plate.

PLATE-IRON GIRDER BRIDGES.

The annexed engravings show the construction of one of the numerous bridges which have been designed by Mr. Martin, the engineer, to carry the railway from the London and North-Western Railway to the East and West India Docks. It carries the railway over Randolph-street, Camden Town.

The peculiarity consists in constructing the bridge with two side girders, each of a single web, of plates of iron, 71 feet long, 6 ft. $7\frac{1}{2}$ inch high, and $\frac{7}{16}$-inch thick; put together with plates 5 inches wide, overlapping the vertical joints, and $\frac{3}{4}$-inch rivets placed 3 inches apart, and fixed to the top and bottom plates by angle-iron 3 inches wide, and $\frac{3}{4}$-inch rivets. The bottom plate is 2 ft. 8 in. wide, made with $\frac{7}{16}$-inch plates in lengths of 8 feet each, with plates overlapping the joints 6 in wide. The outer flange is curved down 1 inch, to throw off the wet; the top plate is 2 ft. 8 in. girt, made with $\frac{7}{16}$-inch plates, excepting the three middle plates, which are $\frac{3}{8}$-inch in thickness; the top is curved down 5 inches, and put together with inch rivets. The girders are stiffened by eight vertical plates on each side of the web, of $\frac{7}{16}$-inch iron, fixed by angle-iron 3 inches wide, and $\frac{3}{4}$-inch rivets placed 4 inches apart. There are also two similar stiffeners at each end, of $\frac{3}{8}$-inch iron. The top plate is further stiffened by stays of T-iron, $5\frac{1}{2}$ inch wide between each pair of stiffeners.

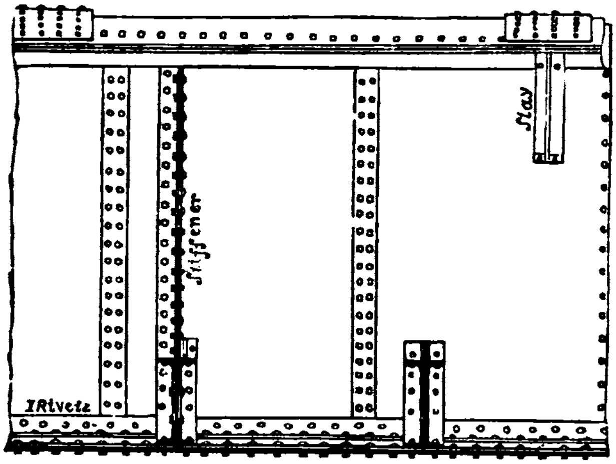


Fig. 2.—Side View of Longitudinal Girder.

The cross girders are 24 ft. 6 in. long and 1 ft. 4 in. high, made with $\frac{3}{8}$-inch plates in three lengths, and stiffened by angle-iron top and bottom and on each side, $3\frac{1}{2}$ inches wide, and fastened with $\frac{3}{4}$-inch rivets 4 inches apart. The ends of these cross girders rest upon the two girders first described.

Fig. 1 is a cross section of the bridge. Fig. 2 is a side view of part of one of the longitudinal girders. Fig. 3 is an enlarged section of one of the girders, showing the stiffeners. Fig. 4 is a section through the same girder, showing the stays to stiffen the top plate.

THE BRITANNIA BRIDGE.

The permanent public opening of the new line of tubes for the down line from London to Dublin took place on Monday 21st ult, the great structure being now in all important respects made complete. On the 19th Oct, Captain Simmons, the Government Inspector, went over it early in the morning, and instituted, in conjunction with the engineers, a long series of experiments.

The first experiment consisted in passing two locomotive engines through the tube, and resting them at intervals in the centre of the sections. At 9 o'clock a train of 28 wagons and two locomotives, with 280 tons of coal, was drawn into all four of the tubes, the deflections being carefully noted. These deflections were ascertained to be exactly three-fourths of an inch under this load. After repetitions of these experimental ordeals, which occupied several hours, the train of 280 tons, with its two locomotives, was taken out about a mile distant from the tube, and then suddenly shot through it with the greatest attainable rapidity, and the result was that the deflection at this immense velocity of load was sensibly less in the way of undulation than when the load was allowed to remain at rest on the tube. The contrivance by which the effects are indicated with great precision consists in a large pipe containing water, laid along the lower cells of the tube, one end rising up within the tube at the centre, and the other end fixed against the stonework of the abutments of the bridge. Both extremities of this pipe are furnished with glass tubes and graduated scales, by which the relative levels of the water were easily ascertained. As the slightest leakage or evaporation over the ordinary thermometric expansion of the water would derange the level, while only half the actual deflection of the tube was registered at each end of the pipe, these disadvantages are obviated by the addition of a large reservoir of water in the interior of the tube, which is covered with oil and placed beside the graduated scale.

Messrs. E. and L. Clark, the resident engineers, who have watched minutely from day to day all the developed peculiarities of the novel undertaking, state that the heaviest gales through the Straits do not produce so much motion over the extent of either tube as the pressure against the side of the tubes of 10 men; and that the pressure of 10 men keeping time with the vibrations produces an oscillation of $1\frac{1}{4}$ inch, the tube itself making 67 double vibrations per minute. The strongest gusts of wind that have swept up the Channel during the late stormy weather do not cause a vibration of more than a quarter of an inch. The broadside of a storm causes an oscillation of less than an inch; but when the two tubes are braced together by frames, which is now being done, these motions, it is expected, will cease. The action of the sun at midday does not move them more than a quarter or three-eighths of an inch. The daily expansion and contraction of the tube varies from half an inch to three inches, attaining either the maximum or minimum at about 3 o'clock a.m. and p.m. If a compass be held over any part of the bottom of the cells, the south pole is affected, and if held over the top of the cells, the north pole is affected; and this effect is observable in all parts of the tube, whether at the centre or the end, although their position is only about 10° west of the magnetic meridian. Preparations are making for covering the tubes with a light arched roof of peculiar construction.

GRAND CONTINENTAL CANAL.

A Belgian engineer, M. de Laveleye, proposes to connect the Seine and the Rhine by means of a canal. This was one of Charlemagne's ideas—equally with that connection of the Rhine and the Danube which has been effected in our own day by means of the Ludwig Canal. The points which M. de Laveleye proposes to connect—Sedan and Trier—are but ninety-five miles asunder, intersected by the rich and populous Grand Duchy of Luxembourg; and presuming the canal to be made, navigation would be open from London to the Black Sea and Constantinople, through the heart of the Continent, and by means of the great watercourses on or near whose banks lie the materials of nearly all the internal and external trade of Europe. Vessels would ascend the Seine from Havre to the junction of the Oise—they would turn up that river and continue to the Aisne—there they would again quit the main stream and proceed to the Ardennes Canal. At Donchery that canal falls into the Meuse, which is navigable already to Sedan. These rivers and canals are at present connected by tributaries and branches with the whole of north-eastern France, from Rouen to the wine-fields of Champagne, and also with the coal and metallic beds of Belgium. Less than a hundred miles of cutting—but through a district of which we suspect all the engineering difficulties are not fairly stated—will connect this immense net-work of navigation with another still larger and more important—of which the Rhine and the Danube are the main highways—Prussia, Germany, Austria, Hungary, and the Eastern provinces are the chief features—and the Black Sea and the Mediterranean are the great outlets. The Moselle already reaches the foot of the Ardennes. From it to the Meuse the distance is what we have stated. From Trier the navigation is open to Coblentz,—the Rhine would carry the vessels up to the Maine,—this river takes them past the trading emporium of Frankfort to the Ludwig Canal, and so into the Danube. On the face of such a project the advantages to France seem to be greater than to any other country—but the subject engages more attention in Vienna than in Paris. The estimated cost is 1,600,000*l.*,—a large sum; but the results are apparently of such magnitude as to insure the execution of the work at some period or other. The whole system of European internal navigation is incomplete so long as the eastern and western branches remain unconnected.—*Athenæum.*

METEOROLOGICAL QUARTERLY REPORT.

On the Meteorology of England and South of Scotland during the Quarter ending September 30, 1850. By James Glaisher, Esq., F.R.S., Hon. Sec. of the British Meteorological Society.

The mean daily temperature of the air was below its average value till July 13; the mean defect was 2·2°; from July 12 to the 24th the period was warm, and the average excess of temperature was 4·8°; from July 25 to August 3 the temperature was below the average; its mean deficiency was 1°; from August 4 to August 18, it was above the average; the mean excess was 2°; this was followed by a long period of fine, clear, dry, but cold weather; the average deficiency of temperature between August 19 and September 17 was 3·5°, and after September 18 the daily temperatures were slightly above their average values. Snow fell on Ben Lomond on August 23rd.

The several subjects of research in the past quarter are detailed below.

The mean temperature of the Air at Greenwich for the three months ending August, constituting the three summer months, was 61·1°, being 1·2° above the average of the 79 preceding summers.*

For the month of July was 62·2°, *exceeding* that of the average of the preceding 79 years by 0·9°, and of the preceding 9 years by 0·7°.

For the month of August was 60·2°, being 0·3° *less* than the average of the 79 preceding years, and 0·9° *less* than that of the preceding 9 years.

For the month of September was 56·4°, *exceeding* the average from the 79 preceding years by 0·1°, and *less* than that of the preceding 9 years by 0·7°.

The mean for the quarter was 59·6°, *exceeding* that of the average of the 79 preceding summer quarters by 0·2°, and *less* than that of the 9 preceding years by 0·3°.

The mean temperature of Evaporation at Greenwich for the month of July was 58·6°; for August was 56·6°; and for June was 52·9°. These values are 0·9° *greater*; 0·2° *greater*, and 1·6° *less* than those of the averages of the same months in the preceding 9 years.

The mean temperature of the Dew Point at Greenwich for the months of July, August, and September, were 55·8°, 53·1°, and 47·7° respectively. These values are 1·5° *greater*, 2·0° *less*, and 4·7° *less* respectively than the averages of the same months in the preceding 9 years.

The mean elastic force of Vapour at Greenwich for the quarter was 0·422 inch; being *less* than the average from the preceding 9 years by 0·008 inch.

The mean weight of Water in a cubic foot of Air for the quarter was 4·8 grains, being of the same value as the average from the preceding 9 years.

The mean degree of Humidity in July was 0·88, in August was 0·81, and in September was 0·75. The averages from the 9 preceding years were 0·79, 0·83, and 0·85 respectively.

The mean reading of the Barometer at Greenwich in July was 29·789 inches; in August was 29·787; and in September was 29·930. These readings are 0·010 *less*, of the *same value*, and 0·121 *greater* respectively, than the averages of the same months in the preceding 9 years.

The average weight of a cubic foot of Air in the quarter was 527 grains, exceeding that of the average of the preceding 9 years by 1 grain.

The Rain fallen at Greenwich in July was 2·9 inches, in August was 1·9 inch, and in September was 1·3 inch. The falls for these months, on an average of 9 years, are 2·3 inches, 2·6 inches, and 2·3 inches respectively.

The average daily ranges of the readings of the Thermometer in Air at the height of 4 feet above the soil, in July was 20·0°, in August was 18·6°, and in September was 17·1°. The averages for these months from the preceding 9 years were 19·4°, 17·6°, and 18·9° respectively.

The minimum readings of the Thermometer on Grass, with its bulb fully exposed to the sky, was at or below 40° on 8 nights; the lowest was 34°; and was above 40° on 23 nights; the highest reading was 55·5°. In August the readings were at and below 32° on 2 nights; the lowest reading was 26°; between 32° and 40° on 6 nights, and above 40° on 23 nights; the highest reading was 58°. In September the readings were at or below 32° on 9 nights, the lowest reading was 24°; between 32° and 40° on 6 nights, and above 40° on 15 nights, and the highest reading was 50°.

The daily horizontal movement of the Air at Greenwich in July was 79 miles, in August was 119 miles, and in September was 82 miles.†

The Temperature of the water of the Thames, from the observations of Lieut. Sanders, R.N., Superintendent of the *Dreadnought* hospital-ship, was 64·6° in July, 63·2° in August, and 57·9° in September.

Thunder Storms occurred on *July* 2 at Liverpool; on the 4th, at Uckfield and Nottingham; on the 9th at Uckfield; on the 15th at Oxford, Aylesbury, Hartwell-house and Rectory; Stone, Holkham, Norwich, and Oxford; on the 16th at Holkham, Hawarden, Liverpool, Manchester, Norwich, Nottingham, and Stonyhurst; on the 17th at Greenwich, Uckfield, Aylesbury, Hartwell, Stone, Linslade, Cardington, Leicester, Greenwich, Nottingham, and s.w. of Dunino; on the 18th at Helston, Exeter, Greenwich, St. John's Wood, Oxford, Aylesbury, Hartwell, Stone, Linslade, Cardington, Leicester, Durham, and Nottingham; on the 23rd at Jersey and Hawarden; at Exeter on the 25th; on the 28th at Guernsey and Helston; on *August* 3 at Rose-hill, Oxford; on the 5th at Holkham; on the 6th at Stone and Dunino; on the 7th at Hartwell; on the 8th at Oxford, Hartwell, Stone, Linslade, Cardington, Hawarden, Liverpool, York, and North Shields; on the 9th at York and Hartwell Rectory; on the 12th at Greenwich, Norwich, and Oxford; on the 13th and 15th at St. John's Wood; on the 19th at Liverpool; on the 20th at Holkham and Nottingham; the 21st at Nottingham; the 24th at Greenwich and Hartwell; the 27th at Guernsey; the 29th at Guernsey and Helston; and on the 30th at Guernsey; on *September* 20th at Exeter; on the 23rd at Holkham and Norwich; on the 24th at Holkham; on the 26th at Stonyhurst; and on the 30th at Jersey and Trowbridge.

At Uckfield, during the third week of July, the weather was wet, and several thunder storms visited many places in Sussex.

At Hartwell Rectory, on July 15th, at 1 h. 30 m., there was a storm, with thunder and lightning, and rain fell to the depth of 0·510 inch: the weather continued stormy with sheet lightning all the evening. On July 17th, at 6 h. 30 m. p.m., there was another thunder storm, but very little rain fell; and sheet lightning occurred at intervals during the evening, to the s. and w. On July 18th, at 3 h. 30 m. p.m., there was a thunder storm, followed by sheet lightning all the evening, with heavy rain falling, amounting next morning to 1·610 inch.

At York, on August 8th, between the hours of 6 and 8 in the evening, there was a thunder storm. The Diocesan School and the Roman Catholic Chapel were struck by lightning, and injured. Sheep were killed, and two individuals were knocked down, but no human life was lost. This was the most severe storm which has visited York for the last 20 years.

At Stonyhurst, on July 16th, the lightning was the most brilliant Mr. Weld ever remembers to have witnessed. The thunder resembled the explosion of fireworks, and on several occasions lightning darted from the same centre in three or four directions: the sky seemed traversed in every direction by streaming lightning of the most vivid description. The thunder was incessant, but very distant, and no rain fell. Mr. Weld heard of seven persons being killed, and about as many more struck, and several valuable cows and horses were destroyed.

Thunder was heard, but Lightning was not seen, on *July* 4 at Guernsey; on the 16th at St. John's Wood, Linslade, Stone, and Wakefield; on the 17th at Greenwich, Durham, and North Shields; on the 18th at Wakefield; on the 19th at Stone; and on the 23rd at Guernsey; on *August* 6th at Oxford, Aylesbury, Holkham, and North Shields; on the 12th at Uckfield, Linslade, Holkham, Hawarden, and Liverpool; on the 13th at Jersey; on the 19th at Norwich; on the 21st at Dunino; on the 23rd at Cardington; on the 24th at Exeter, Oxford, Hartwell Rectory, and Stone; and on the 28th at Nottingham; on *September* 3rd and 24th at Aylesbury; on the 26th at Durham and North Shields; and on the 27th at St. John's Wood.

Lightning was seen, but Thunder was not heard on *July* 8th at Uckfield; on the 15th at Uckfield, Hartwell Rectory, Stone, and Stonyhurst; on the 16th at Leicester, Nottingham, and Manchester; on the 17th at St. John's Wood, Oxford, Hartwell Rectory, and Liverpool; on the 19th at Stone; and on the 29th at Manchester; on *August* 5th at Cardington and Stone; on the 6th at Highfield House; on the 8th at Stonyhurst; on the 9th at Cardington; on the 16th at North Shields; on the 22nd at Norwich and North Shields; on *September* 23rd at Uckfield, Greenwich, Linslade, and Cardington; on the 24th at Greenwich, Oxford, and Stone; on the 29th at Hartwell Rectory; and on the 30th at Helston, Uckfield, Greenwich, St. John's Wood, Oxford, Hartwell Rectory, and Linslade.

Auroræ Boreales were seen at Norwich on July 5th; on the 12th at Norwich; on August 6th at Stone; on the 21st at Stone and Dunino; on September 6th and 10th at Nottingham; on the 13th at Nottingham and Hawarden; on the 14th at Stone; and on the 28th at Hartwell House, Hartwell Rectory, and Stone.

Hail fell on July 12th at Hawarden; on the 20th at Oxford and Liverpool; and at Dunino on the 21st and 22nd; on September 29th at Guernsey; and on the 30th at Jersey.

Snow fell on Ben Lomond on August 23rd.

Meteors.

At Uckfield meteors were very numerous during the nights of July 12, 16, 30; and August 9; September 10, 11, and 12.

At Hartwell Rectory, on August 11, a large meteor was seen at 10h. 10m. p.m.

At Stone, on July 13, at 11h. 20m. p.m., a meteor passed from Arcturus to Peterson's comet.

On July 29, at 9h. 57m. p.m., a meteor crossed Corona Borealis from n. to s.

September 6, at 11h., a meteor passed from Pisces to Fomalhaut.

September 17, at 10h. 4m. p.m., a meteor passed from α Corona Borealis to 4° above Saturn.

September 28, at 9h. 30m., a meteor as bright as Capella shot from α Draconis to γ Ursæ Majoris.

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* See my paper in the *Philosophical Transactions*, part II, 1850, upon the temperature &c., of the years from 1771 to 1849; and also see the *Illustrated London Almanack* for 1851, for some particulars of all those years.

† See the *Philosophical Magazine* for November for Wind Tables, &c.

At Stonyhurst, fine meteors were seen on August 14, 23, 26, and 29.

At Highfield House, near Nottingham, on July 4, at 9h. 26m. p.m., a meteor, which increased in brilliancy and size as it progressed, until, from a mere point, it attained a size equal to three times the apparent diameter of Jupiter, and nearly six times the brightness of that planet; its colour was pale blue, and it fell nearly perpendicular downwards, inclining very slightly towards the E.; it passed from halfway between λ and θ Antinous, fading away 2° to the east of α Capricorni, and on the same level with that star. Its motion was slow, duration 2s.; at first was unaccompanied by sparks; finally it suddenly separated, and almost instantly vanished.

On July 9th, at 10h. p.m., a meteor was seen of twice the size of Jupiter, and similar in colour; it fell downwards from Coma Berenicies.

On August 1, at 10 p.m., a small meteor, with a train of light, fell downwards from α Aquilæ.

On August 3, at 10h. 55m. p.m., a meteor, equal in size to a star of the fifth magnitude, fell rapidly from α Corona Borealis to ξ Bootes; its duration was 0·5s, and it became extinct instantly.

On August 6, at 10h. p.m., three small meteors were seen; another meteor was seen at 10h. 22m. p.m., which fell from ε Pegasi to β Aquarii, leaving a train of light for 20s. afterwards.

On August 8, at 10h. 20m. p.m., a meteor was seen by A. S. H. Lowe, Esq., which fell from ε Ursæ Majoris; at 11h. 15m. p.m., a meteor fell from α Ophiuchi.

On August 9, at 11h. 15m. p.m., two meteors were seen, one being in the zenith.

On August 12, at 10h. 32m. p.m., E. J. Lowe, Esq., saw a meteor, which moved horizontally, and increased in brilliancy from being equal to a star of the fifth to one of the second magnitude; its colour was blue, and duration 0·2s.; its path was from 24 Camelopardalis towards λ Draconis.

On August 12, at 10h. 33m., a meteor passed from τ Cassiopeiæ towards θ Ursæ Majoris, and was equal in size to a star of the third magnitude; its colour was blue, and its duration 0·5s.

On the same night, at 11h. 9m., a meteor fell from between β, γ, and λ Pegasi perpendicularly down to within 20° of the horizon, when it went behind a cloud, and from one to two seconds after, a flash, resembling lightning, and quite as vivid, proceeded from behind the cloud, followed immediately by a second flash; the meteor itself was about 12′ in diameter, was globular in form, and yellow in colour; it moved very slowly; this meteor was followed by a train of light.

On August 14, at 8h. 45m. p.m., a meteor was seen four or five times larger than Jupiter; it was a pale straw colour, very globular in form, with a red-defined disc, no train of light visible; it fell between λ Bootes and η Ursæ Majoris perpendicularly downwards; it passed 3° or 4° north of the large group of stars in Coma Berenicies; its duration was 2s.

On August 14, at 9h. 48m. p.m., a small meteor moved from 24 Camelopardalis to Ursæ Majoris; its colour was blue, and duration 0·5s.

On the same night, at 9h. 49m. p.m., a meteor fell perpendicularly down from α Cassiopeia; it was about the size of a star of the third magnitude, and of a blue colour.

On August 22, at 10h. p.m., a meteor fell from ε Cephei through λ Andromedæ.

On August 22, at 10h. 24m. p.m., a meteor was seen about the size of Arcturus, and of a yellow colour; it fell perpendicularly down, inclining to the north from 5° below γ Bootes.

On August 29, at 9h. 59m. 35s., a meteor of the size of a star of the third magnitude was seen; it was blue in colour, and moved very rapidly; it passed from η Bootes to Arcturus; its duration was 0·5s.

On August 29, at 10h. 1m. p.m., a meteor of the size of a star of the second magnitude was seen; its colour was red; it left a train of red sparks, and moved rapidly from γ Trianguli to Saturn.

On August 29th, at 10h. 4m. p.m., a meteor was seen of an orange scarlet colour; it moved slowly from ε Persei to near 21 Pegasi in a horizontal direction; its duration was 2s.; when first seen it was equal to a star of the fifth magnitude, but gradually increased in diameter as it progressed, until it became three times as large as Saturn; there was no large ball of light; it disappeared suddenly.

On the same night, at 10h. 7m. p.m., a meteor was seen, which moved rather slowly; was of a blue colour, with a slight tail; duration 1s.; in size superior to a star of the second magnitude.

On September 1, at 9h. 5m., a meteor was seen in the zenith.

On September 2, at 11h. 13m., a meteor was seen passing rapidly from δ Equulii.

On the same night, at 11h. 16m., a similar one from ε Aquarii to β Capricorni.

On the same night, at 11h. 19m., a meteor passed from Aldebaran to β Ophiuchi.

Again, on the same night, at 10h. 20m., from η Ursæ Minoris to ε Ursæ Majoris; duration 1s.; colour yellow.

On September 28, at 10h. 45m., p.m., a meteor which moved from S.S.E. to S.W., at an elevation of 45°, leaving a long train of light behind, was seen.

Frost.—The first frost was seen on August 22nd, at Uckfield, when wheat and barley sheaves were frozen into a stiff mat; and Mr. Prince saw ice as thick as a wafer upon his cucumber frames. On September 5th there was a sharp frost at Hartwell House; and at Trowbridge, September 7th and 8th.

Solar halos were seen on July 6th at Uckfield; on the 10th near Oxford and Nottingham. On August 3rd at Dunino; on the 7th at Greenwich; on the 20th at Dunino; on the 28th at Uckfield; and on the 29th at Exeter and Nottingham. On September 12th at Guernsey; and on the 29th at Dunino.

Lunar halos were seen on July 22nd at Stone, Nottingham, and Norwich. On August 21st at Uckfield and Nottingham; on the 22nd at Uckfield, Oxford, Cardington, and Nottingham; on the 23rd at Uckfield and Nottingham; on the 24th at Hawarden; on the 26th at Stonyhurst; and on the 31st at Durham. On September 18th at Jersey, Guernsey, Oxford, and Hawarden; on the 21st at Oxford, Hartwell Rectory, Cardington, Stone, and Durham; on the 22nd at Oxford, Hartwell Rectory, Cardington, Norwich, and Stone; on the 24th at Oxford; on the 25th at Cardington; and on the 26th at Durham.

Lunar Corona were seen at Hartwell Rectory on August 14th and 16th.

Lunar Rainbows were seen on August 20th at Exeter; on August 22nd, at 10 h. 40 m. p.m., at Battersea Bridge, London, as seen by the Rev. Charles Lowndes.

Fog, on July 11th at Stone; on the 12th at Stone and Hartwell. On September 11th at Greenwich; on the 12th at Stone, Hartwell House, and Trowbridge; on the 14th at Stone, Hartwell, and Trowbridge; on the 15th at Hartwell and Trowbridge; on the 18th at Trowbridge; on the 19th at Hartwell and Trowbridge; on the 24th at Stone and Hartwell; and on the 25th at Stone, Hartwell Rectory, and Greenwich.

Remarkable Rain.

At Guernsey, on August 8th, rain to the depth of 1·333 inch fell in 16 hours; and on September 28th upwards of one inch of rain fell within 12 hours.

At Falmouth, on September 24th, rain to the depth of 1·93 inch fell, of which 0·8 inch fell in little more than half an hour.

At Exeter, from August 25th to September 19th, no rain fell, and the weather was clear, warm, and fine, for several days—the sky was cloudless: the average reading of the barometer was about 30·25 inches.

The amount of rain which fell during the thunder storm on September 20th was 1·95 inch, which is the amount by which the rain in the month exceeded the average, the former being 4·33 inches, and the latter 2·39 inches, or rather more than one-half.

At Uckfield, on July 17th, the depth of rain which fell within an hour was 1·81 inch, which is an almost unprecedented amount to have fallen in so short a time in the south of England. Much heavy rain fell during the last week of September, which was very beneficial to the autumn crops.

At Southampton no rain fell till the 21st of September, and on September 27th it fell to the depth of 1·13 inch.

At Aylesbury, on July 15th, rain to the depth of 0·75 inch fell in 42 minutes. No rain fell from the 27th of August to the 20th September, and much inconvenience is still felt from the short supply of water.

At Derby, the amount of rain which has fallen in the nine months of this year is 15·6 inches; the average is 22·4 inches.

At Norwich, on July 26th, rain fell to the depth of 1·18 inch.

At Holkham, on July 16th, rain fell to the depth of 1·29 inch in 5¾ hours.

At York, on August 8th, rain to the depth of 0·74 inch fell within two hours. No appreciable quantity of rain fell in York between the 28th of August and the 20th of September.

At Stonyhurst, on August 5th, rain fell to the depth of 0·784 inch; and on August 7th to the depth of 0·858 inch.

At North Shields, on July 25th and 26th, rain fell to the depth of 1·482 inch. The month of September was remarkably fine and dry till the 20th; on that day there was a heavy fall of rain, amounting to 0·76 inch in five or six hours.

The following observations of natural phenomena were taken at Highfield House, near Nottingham (being nearly the centre of England) by E. J. Lowe, Esq., F.R.A.S.

July 1. Tulip tree in full flower.
.. 4. Cherries ripe.
.. 7. Enothera mecrocarpa just in flower; black currants ripe; red currants scarcely ripe; white currants scarcely ripe
.. 17. Lime tree in full flower; strawberries, excepting the late varieties (as Cox's scarlet, British Queen), going over; raspberries, many ripe
.. 23. Field of turnip seed cut; field of pease cut
.. 28 Strawberries nearly over; picotees in full flower; carnations just in flower; hollyhocks coming into flower
Aug. 1. Field of wheat sheared at Lenton
.. 6. Oats cut at Beeston
.. 7. Oats cut near Nottingham; wheat cut at Beeston
Aug. 11. Apricots ripe
.. 12. Pears (Green Chisel) ripe; apples Juneaton) ripe
.. 13. Some oats led away; some wheat led away
.. 21. Gooseberries over; currants over
.. 22. Frost injured half hardy plants
.. 26. Mountain ash-berries quite ripe; corn nearly all harvested
Sept. 1. Blackberries ripe
.. 5. Peaches ripe; apple (Keswick) nearly ripe; wall plums nearly ripe
6 and 7. Few wasps about; they are very scarce this year
.. 17. Nectarines ripe; plums (Victoria) ripe; (Emperor) ripe; dahlias in full glory of bloom; autumn roses in bloom
.. 19. plums (damson) ripe

The following table contains the mean quarterly values of the several subjects of investigation.*

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* See the Quarterly Report of the Registrar-General for the monthly values at all the stations.

Quarterly Meteorological Table for the Quarter ending September 30th, 1850.

The observations have been reduced to mean values, and the hygrometrical results have been deduced from "Glaisher's Tables."

Names of the Places.	Mean Pressure of Dry Air reduced to the level of the Sea.	Mean Temperature of the Air.	Highest reading of the Thermometer.	Lowest reading of the Thermometer.	Mean Daily Range of Temperature.	Mean Monthly Range of Temperature.	Range of Temperature in the Quarter.	Mean Temperature of the Dew-Point.	Wind. Mean Estimated Strength.	Wind. General Direction.	Mean Amount of Cloud.	Rain. Number of Days on which it fell.	Rain. Amount Collected.	Mean weight of Vapour in a cubic foot of Air.	Mean additional weight of water required to saturate a cubic foot of Air.	Mean degree of Humidity.	Mean whole amount of Water in a Vertical Column of Atmosphere.	Mean Weight of a cubic foot of Air.	Height of Cistern of Barometer above the Level of the Sea.	Names of the Observers.
	in.	°	°	°	°	°	°	°					in.	gr.	gr.		in.	grs.	ft.	
Jersey	29·652	60·2	81·0	48·0	14.4	30·7	33·0	54·5	1·7	S.W.&N.W.	4·8	36	6·4	4·9	1·5	0·822	6·0	529	84	Rev. Samuel King, F.R.A.S.
Guernsey	29·599	60·1	75·5	51·5	18·9	19·2	24·0	56·2	1·7	W. & E.	4.9	36	8·8	5·2	0·6	0·898	6·4	528	123	Dr. Hoskins, F.R.S.
Helston	29·614	58·7	80·0	40·0	15·3	35·3	40·0	54·6	1·4	S.W.&N.W.	5·8	37	7.8	4·9	0·9	0·839	6·0	528	106	M. P. Moyle, esq.
Falmouth	..	59·1	78·0	40·0	18·5	33·3	38·0	..	1·4	N.	6·6	33	10·8	..	..	..	..	..	120	L. Squire, esq.
Truro	29·694	58·5	77·0	39·0	14·8	34·3	38·0	53·7	1·0	N.	5·9	41	4·8	4·8	1·0	0·834	5·9	530	55	Dr. Barham.
Torquay	..	60·5	77·0	47·0	12·2	24·3	30·0	52·8	2·3	N.	..	29	8·0	4·7	1·3	0·780	5·7	..	160	Edward Vivian, esq.
Exeter	29·600	59·1	81·6	40·7	15·8	35·7	40·9	53·1	1·7	W.	3·7	36	8·0	4·7	1·2	0·804	5·9	529	140	Dr. Shapter.
Uckfield	29·598	59·5	89·0	34·0	22·3	45·3	55·0	51·8	..	W.	..	35	7·4	4·8	1·5	0·747	5·5	528	180	C. L. Prince, esq.
Southampton	29·589	59·7	81·0	36·0	17·0	35·9	45·0	..	0·3	..	6·1	33	9·1	..	..	..	6·3	..	55	John Drew, esq., F.R.A.S.
Greenwich Royal Observatory	29·609	59·6	87·0	39·0	18·6	38·0	48·0	52·2	..	N.E. & S.W.	..	39	6·1	4·6	1·2	0·788	5·6	527	159	The Astronomer Royal
Maidenstone Hill, Greenwich	29·608	58·5	84·3	39·6	14·6	35·9	44·7	54·8	..	N.E. & S.W.	6·8	33	5·7	5·0	0·7	0·872	6·1	529	107	Mr. William Ellis
St. John's Wood	29·649	57·5	83·0	38·0	16·0	37·0	45·0	49·6	..	..	..	46	5·8	4·1	1·2	0·779	5·1	530	150	George Leach, esq.
Chiswell-street, London	..	61·2	80·0	46·0	11·4	27·3	34·0	51·5	..	..	..	37	5·9	4·5	1·8	0·716	5·5	527	..	David Slate, esq.
Aylesbury	29·650	59·2	86·0	32·0	24·2	46·4	54·0	51·1	0·7	S.	6·5	37	7·5	4.4	1·4	0·765	5·4	525	284	Thomas Dell, esq.
Stone Observatory	29·600	57·8	85·5	33·0	19·9	42·0	52·5	50·7	..	S.W.	5·6	46	5·8	4·3	1·2	0·784	5·4	523	310	Rev. J. B. Reade, F.R.S.
Hartwell (near Aylesbury)	29·580	58·6	88·0	32·0	23·4	46·0	56·0	52·6	0·9	N.N.W.	..	32	6·1	4·6	1·0	0·817	5·3	525	250	Dr. Lee, F.R.S.
Hartwell Rectory	29·602	57·1	81·5	33·5	17·2	39·6	48·0	49·6	0·6	N.W.&S.W.	5·8	39	6·9	4·2	1·3	0·771	5·1	526	290	Rev. C. Lowndes, F.R.A.S.
Linslade (Bucks)	..	57·2	85·5	35·0	19·3	40·5	50·5	..	..	S.W.	..	43	7·0	..	..	..	..	..	513	John Osborn, esq., Junr.
Radcliffe Observatory, Oxford	29·638	57·2	79·6	35·1	15·8	35·6	44·5	51·5	1·9	N.E. & S.W.	7·2	38	8·0	4·5	1·0	0·813	5·5	528	210	M. J. Johnson, esq., F.R.A.S.
Rose Hill (near Oxford)	..	..	84·5	36·5	..	36·9	48·0	..	..	..	..	36	7·8	..	..	..	..	..	270	Rev. J. Slatter, F.R.A.S.
Cardington (near Bedford)	29·604	58·0	83·5	35·0	19·6	40·9	48·5	52·4	0·9	Var.	7·1	38	6·6	4·6	1·1	0·806	5·7	529	100	S. C. Whitbread, esq., F.R.A.S.
Norwich	29·536	57·8	81·0	41·0	16·8	34·0	40·0	52·8	..	S.W.&N.W.	6·9	43	10·2	4·7	0·9	0·848	5·7	530	23	C. Brooke, esq., F.R.A.S.
Leicester Museum	29·538	56·8	79·0	38·0	14·4	32·6	41·0	50·0	1·3	W.	7·5	31	6·1	4·3	1·1	0·791	5·2	527	175	John Stallard, esq.
Holkham	29·610	57·1	80·8	37·5	14·6	36·6	43·3	51·3	1·1	N.W.	6·4	47	9·2	4·4	1·0	0·821	5·4	531	39	The Earl of Leicester.
Highfield House, Notts	29·557	57·2	87·3	33·0	21·6	45·2	54·3	53·1	0·4	Var.	6·5	47	7·1	4·7	0·7	0·865	5·8	529	103	E. J. Lowe, esq., F.R.A.S.
Derby	29·586	56·5	82·0	..	..	..	..	52·8	..	S.E.	..	43	6·9	4·7	0·8	0·856	5·7	530	..	John Davis, esq.
Hawarden	29·649	56·5	81·5	39·5	12·7	28·0	42·0	48·8	1·7	N.W.	7·0	44	7·7	4·1	1·3	0·763	5·0	528	260	Dr. Moffatt, F.R.A.S.
Liverpool	29·592	58·1	80·9	46·3	10·2	24·9	34·6	54·0	1·3	N.W.	7·6	43	7·8	4·7	0·9	0·837	5·7	530	37	John Hartnup, esq., F.R.A.S.
Wakefield	29·585	55·6	82·0	31·0	21·4	44·2	52·0	52·2	2·0	W.	6·7	48	6·7	..	..	..	..	..	115	W. R. Milner, esq.
Stonyhurst	29·629	54·9	77·6	35·2	..	..	42·4	50·0	1·3	E. to W.	6·8	49	12·2	4·3	0·8	0·818	5·2	527	381	Rev. A. Weld, F.R.A.S.
York	29·612	55·7	78·0	35·0	14·5	36·0	43·0	50·9	..	Var.	..	38	6·4	4·3	0·9	0·833	5·3	530	50	John Ford, esq.
Whitehaven	29·547	56·4	84·0	39·5	12·8	31·2	44·5	53·6	3·1	N.W.	..	43	12·5	4·6	0·6	0·880	5·5	532	80	J. F. Miller, esq., F.R.S.
Durham	29·596	53·9	76·8	34·8	14·8	34·3	42·0	49·4	0·8	S. & W.	6·3	44	6·3	4·2	0·8	0·828	5·1	528	340	R. C. Carrington, esq.
Newcastle	..	55·5	76·0	37·0	14·8	33·0	39·0	51·6	..	S. W. & E.	..	30	..	4·5	0·7	0·870	5·5	532	..	George Muras, esq.
North Shields	29·668	53·5	70·4	36·8	11·1	30·0	33·6	50·8	2·8	N.E.&S.W.	3·4	50	6·6	4·4	0·4	0·927	5·3	535	124	Robert Spence, esq.
Glasgow	29·555	55·8	79·9	39·0	14·7	33·2	40·9	49·8	..	..	..	..	7·9	4·2	1·0	0·810	5.2	530	121	Dr. R. D. Thomson.
Dunino	..	56·3	81·0	37·0	20·0	39·0	44·0	49·1	1·9	Var.	3·8	31	6·2	4·4	1·2	0·792	5.0	..	250	David Tennant, esq.

The mean of the numbers in the first column is 29·605 inches, and it represents that portion of the reading of the barometer due to the pressure of air; the remaining portion, or that due to the pressure of water, is 0·397 inch: the sum of those two numbers is 30·002 inches, and it represents the mean reading of the barometer at the level of the sea for the quarter ending September 30, 1850.

Quarterly Meteorological Table, for different Parallels of Latitude.

Parallels of Latitude, &c.	Mean Temperature of the Air.	Mean of Highest Readings of the Thermometer.	Mean of Lowest Readings of the Thermometer.	Average Daily Range of Temperature.	Average Monthly Range of Temperature.	Average Quarterly Range of Temperature.	Mean Temperature of the Dew-Point.	Mean amount of Cloud.	Rain. Average Number of Days.	Rain. Average Fall.	Mean Weight of Vapour in a cubic foot of Air.	Mean Additional Weight required to saturate a cubic foot of Air.	Mean degree of Humidity.	Mean whole amount of Water in a vertical Column of Atmosphere.	Mean Weight of a cubic foot of Air.	Mean Height above the Sea.
	°	°	°	°	°	°	°			in.	gr.	gr.		in	gr	ft.
Guernsey and Jersey	60·1	78·3	49·8	11·7	25·0	28·5	55·4	4·9	31	7·6	5·1	1·0	·860	6·2	529	104
In the Counties of Cornwall and Devonshire	59·2	78·7	41·3	15·3	32·5	[illegible]	53·5	5·5	35	7·8	4·8	1·1	·814	5·9	529	116
South of Latitude 52°	58·4	84·6	35·3	19·0	39·9	49·0	51·5	6·3	38	6·9	4·5	1·2	·793	5·6	527	232
Between the Latitudes of 52° and 53°	57·3	82·3	36·9	17·5	36·7	42·0	[illegible]	6·9	42	7·7	4·6	0·9	·829	5·6	529	86
Between the Latitudes of 53° and 54°	55·7	80·0	35·2	16·2	36·1	45·7	50·5	6·8	45	8·3	4·3	1·0	·811	5·2	529	202
Liverpool and Whitehaven	57·3	82·5	42·9	11·5	28·0	39·6	53·3	7·6	43	10·2	4·4	0·8	·859	5·6	530	58
Durham, Newcastle, & North Shields	54·3	74·4	36·2	13·6	32·4	38·2	50·6	4·9	41	6·5	4·4	0·6	·875	5·3	532	232
Glasgow and Dunino	56·1	80·5	38·0	17·4	30·1	42·4	49·4	3·8	31	7·1	4·3	1·1	·801	5·1	530	186

The highest reading of the thermometer in air was 89° at Uckfield, 88·5° at Linslade, and 88° at Hartwell; and the lowest readings were 31° at Wakefield, and 32° at Aylesbury and Hartwell. The extreme range of temperature, therefore, in England, during the quarter, was about 66 .

The least daily range of temperature took place at Guernsey, Liverpool, and North Shields; the mean value was 10·1°; and the greatest occurred at Uckfield, Aylesbury, and Hartwell, and the mean value was 23·3°.

The least monthly range of temperature occurred at Guernsey, Liverpool, and Torquay, and their mean value was 23·4°. The greatest monthly ranges occurred in the vale of Aylesbury and at Uckfield, and was 45·9°.

The average range of temperature in the quarter, at Uckfield, Hartwell, and Highfield House, was 55°; and at Guernsey, Jersey, and North Shields, was 30·2°.

Rain fell, on the least number of days, at Jersey and Torquay; and on the greatest number of days, at Wakefield, Stonyhurst, and North Shields. The places where the least falls took place are London and Truro; and the mean amount at those places was 5·3 inches. The largest falls occurred at Whitehaven and Falmouth, and their average was 11·6 inches.

Agricultural Reports.

Wheat began to be gathered in Jersey on July 15th, and on July 29th cutting of oats; at Hawarden, Guernsey, and Exeter on July 30th; on August 1st at Nottingham; on the 2d at Linslade and Cardington; on the 3rd at Leicester; on the 5th at Aylesbury; on the 8th at Oxford; on the 9th at Holkham; on the 12th at Durham; on the 19th at Stonyhurst and North Shields; and on the 26th at Dunino.

Harvest finished, on August 30th at Guernsey; on the 31st at Cardington; on September 5th at Holkham; and on the 21st at Hawarden.

Uckfield.—August was very showery throughout, and the weather very unfavourable for securing the harvest. The mean temperature was below the average, and there was a remarkable absence of sunshine; an unusually low temperature occurred on the morning of the 22nd, the minimum being 34°, and on the grass 32°: in some situations it fell to 30°. The sheaves of wheat were *frozen* quite stiffly together, and ice was observed on good radiating surfaces. August 21st had been a very wet day, and rain fell to the depth of 0·77 inch, and the atmosphere became suddenly clear, and cold after sunset.—September was very fine and dry to the 20th day: this fine weather was much wanted for completion of harvest and the commencement of hop-picking in this locality. The barometer was very high during this period, and the wind veered only from N. W. to E.—The potatoe disease appeared in this neighbourhood on July 14th, and during the succeeding fortnight spread with great rapidity. Although the haulm was for the most part destroyed, yet the tubers were not so much diseased as they were in the summers of 1845 and 1848; and had July been a dry month, the probability is, that the disease would scarcely have been observed.

Hartwell Rectory.—The harvest has been gathered in a much shorter time than usual, the weather having been very favourable. The crop of peas and beans was very much blighted through the whole district; and in some few instances were not considered sufficiently good to cut and gather. The produce of the crops of wheat, barley, and oats does not come up to the average. The potatoe crop has turned out much better than was expected, there being very little disease.

Rose Hill, Oxford.—"The early potatoes were taken up by the 12th of July, with only one root bad out of a large quantity. This was a root of which the leaves were much cut by the frost in May; the main crop, however, continued flourishing till August the 3rd. After the thunder storm on that day they drooped their heads, and on the 5th were quite prostrate, and the disease was very prevalent in this neighbourhood. When the stalks decayed, a minute fungus appeared beneath the epidermis. It seems plain that the disease first causes the destruction of the leaves; and then the roots, if not near maturity, become surcharged with moisture and perish. My belief is, that the mode of culture is the secret; and potatoes whose roots were beneath the affection of sudden atmospheric changes, were safe.."—Rev. J. Slatter.

Highfield House, near Nottingham.—On the whole the crop has been a poor one. Wheat not an average, and both quality and yield inferior. Barley not an average; oats not an average, yet better than wheat or barley. Turnips much destroyed by fly in the dry weather. Potatoes a fair crop, and not so much diseased as in former years. Beans sadly deficient. Hay crop was very light; and hay is now selling at from 4*l.* to 4*l.* 10*s.* per ton. Apples a very poor crop, most having been blown off by heavy gales. Pears deficient. Plums deficient. Peaches and nectarines a very poor crop. Apricots below an average. Strawberries below an average. Raspberries and gooseberries very good crop. Currants a good crop. Wasps have been rare this year. Mushrooms a poor crop owing to the dry weather at Midsummer. The trees have not made their second growth.

North Shields.—The harvest was almost all gathered in during the early part of the month, but the crops had suffered very much from the effects of wind, on the 18th, 19th, 25th, and 26th of August.

Stonyhurst.—There was an average crop of hay this season, and it was for the most part well got in.—Wheat has succeeded well; the grain was well saved, and it was all housed by September the 2nd.—The season has been very unfavourable for oats; in many instances the early shoots were blighted, and those which succeeded them never came properly to maturity.—Though the crop is generally housed, there are still many fields out, and, in some instances, they are now reaping grain, which is still very far from being ripe.—Signs of disease appeared in potatoes about July 17, but in the roots only, the tops not being affected. About August 19 the tops were very generally blighted. About September 20 it was observed in many fields which had been newly ploughed this season, that about one-third of the crop was diseased, though in some places only one-sixth part was affected. The extent of the disease was found to vary very much even in the same field.—In fresh ploughed peat-land situated very high the crop was healthy, and almost cut, only about one-ninth part being diseased.—The turnip crop received a severe check at the early part of the season. The same is the case with regard to mangel-wurzel, which promises only an indifferent crop.—Beans have succeeded remarkably well this year.—During the summer pleuro-pneumonia has been frequent amongst the cattle.

CURVE OF GOTHIC ARCHITECTURE.

"*On the Curve of Gothic Architecture.*" By Mr. Laker. (Paper read before the Liverpool Architectural and Archæological Society, October 16th, C. Barber, Esq., V.P., in the Chair.)

After introducing his subject, Mr. Laker vindicated the terms Gothic and English, as applied to this style of architecture, on account of our Teutonic descent, and the great examples of the style being found in England. He claimed the distinction of Poetry for the Greek and Gothic styles, which was wanting in the Roman styles. Both the Greek and the Gothic were constructed upon curved lines—the Greek upon conic sections, and the Gothic upon similarly modified curves. The Roman was constructed upon circular curves only, and the Poetry was lost. One great writer upon architecture had said, that in coming out of a Gothic cathedral, and entering St. Paul's, "I have left the regions of Poetry, and have come into the regions of common-sense—Prose." (He might have expressed himself with equal accuracy had he said he had left the region of *Architecture*, and come into the region of common-sense—*Building*.) With regard to the Gothic curve when applied to groining, it had been elliptic, or struck from four centres, from the period of its introduction: but for obtaining these centres we had nothing to guide us. Mr. Willis, and all the late writers on Architecture, had admitted this; and Weale's lately published Atlas had exhibited the subterfuges resorted to, to obtain a correspondence between the long and short ribs. The fundamental rule, that the curves should spring from the line of the impost, was abandoned; one centre was to be taken a little above this line, another a little below it; and one was actually to be stilted so much, as to spring about midway between the impost and the roof. He (Mr. Laker) proposed to furnish a principle which would give the centres of all these curves with perfect certainty and perfect harmony, at the same time furnishing what was stated to be a further requisite, an independent projection for each rib.

Given the height and width of the arch required, the centres were found in every instance independently, and with mathematical precision. On the width and height of the arch construct a right-angled triangle. From the ine, A C (fig. 1) drop a perpendicular to the point B. From C to E will furnish the radius of the arch from the impost. Then construct another right angle triangle by drawing A H parallel to E B, and the length of A H added to E C will give the radius for striking the upper portion of the arch. The principle was equally applicable to arches higher than their width, but in this case the second radius will be obtained by the line parallel to E C (fig. 2) being drawn from the upper angle B, and the right angle constructed with B C; which, however, is only added to show that the whole scheme is constructed on one series of angles, the triangles A B C, A E C, and A B H, or B C H being precisely similar in character.

Fig. 1.

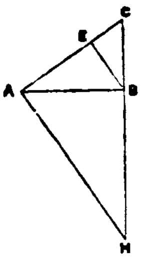
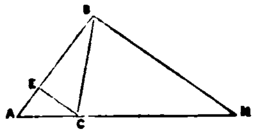


Fig. 2.



Mr. Laker referred to specimens from Lincoln and Chichester Cathedrals, King's College Chapel, and Crosby Hall, which were referable to his principle, and he showed a diagram of the ribs of groin constructed on this principle, adapted to the angle of the nave and transept of Salisbury Cathedral.

The Vice-President thanked Mr. Laker for his paper, but was more disposed to trust to taste than mathematics.

Mr. Frank Howard was glad to find another fellow-labourer in the endeavour to reduce beauty of proportion to mathematical precision; Schlegel had observed, that there were a certain class of persons who studiously veiled their remarks in indefinite terms, that they might not be called on to support any position they might have taken up. Mr. Howard would condense what might be collected from the rest of Schlegel's works—that the class of critics objected to strict definition of what was good or bad, for fear they should be found on the wrong side. He would ask, "What is taste but an appreciation of that beauty which is acknowledged by the mass of mankind?" The problem to be solved was, in what did that beauty consist? He was quite prepared to admit Mr. Laker's principle as *one* means of solution, as regarded the striking Gothic arches, but would not like to pledge himself to its being the *only* mode of obtaining beauty therein.

An animated conversation then took place, in which Mr. Duncan, Mr. Goodall, and Mr. Huggins expressed their opinions that it would fail when practically applied to vaulting, the curves for which they could only be practically obtained by a regular curve and co-ordinates, so as to produce conic sections.

Mr. Boult was of opinion that Mr. Laker and Mr. Howard were desirous of carrying a good principle too far; and, while he agreed with a great deal of the paper just read, he could wish to see a model of a groin constructed upon the principle propounded, and the several arches struck on paper, and cut out so that they could be applied to test the ribs of the model. In this way they would be able to judge of the effect of the groin thus constructed, and, at the same time, to be satisfied as to the mode of striking the arches.

Mr. Barber repeated that he thought the beauty must depend upon taste and not upon rule. He would say to the students, "Cultivate your taste."

Mr. Laker, in reply, stated that it was admitted in all works on architecture that rules were required, but that no rule had yet been laid down for the striking the arches in question. He suggested his method as meeting all the requisitions. If any other could be found he would be very glad to see it.

INTERRUPTION TO THE RIVER CLYDE NAVIGATION.

The steam-ship *City of Glasgow* started out on her final voyage for America from the Clyde on Saturday the 12th Oct., leaving the Broomielaw at half past eleven o'clock, p.m. On getting the length of Erskine, she grounded, and on floating again, during the night, only got the length of Bowling Wharf, where she remained till next forenoon, for reasons which we will presently explain.

We must preface that the bank she first rested upon is an accumulation of sand, that regularly, every two years and a-half, gathers at a well-known spot, near Erskine Ferry, where the *dyke* of the river Clyde, on the south side, is not continued for a length of about three miles. It is in consequence of the non-continuance of this dyke tha the bank arises, and will continue to arise, till the gap in the dyke be filled up, and the scouring properties of the tide made available for the deepening of the channel, same as at other parts of the river. The removal of this bank costs the Clyde Trustees about 3000*l.* every two years and a-half, or at the rate of about 1200*l.* per annum, not to speak of the loss to the shipping trade by the detention and damage done to their vessels by it.

We now come to the reasons for the *City of Glasgow* being a second time detained, and they are these:—At the end of the gap in the river dyke, or a little below it, there is another bank, which is likewise formed every two years and a-half exactly upon the principles as that of the upper one, with this difference, that whereas the gap at the upper end precipitates the sand on the ebbing of the tide, that at the lower end acts with a similar result on the flowing of the tide; the expense for the removal of said obstacle to the Trustees being likewise about 3000*l.*, or, together, the two incumbrances cost the public about 2400*l.* per annum, exclusive of other disadvantages already alluded to. But it so happens, that when a vessel grounds during the day on the upper bank, and lies till the flowing of next tide, though she should have sufficiency of water, on floating, to get her over the lower one, she has not daylight to do so, particularly in winter, and hence if the night be stormy or dark, or otherwise unpropitious—and ten chances to one but it is so at this season of the year—she is necessitated, under the pilot's orders, to remain another tide, whatever be the views of the master, or the urgency of the voyage.

Now who is to blame for this? Not the River Trustees; for, time after time, they have endeavoured to get power by their several Acts to continue the river dyke for the three miles alluded to. Not the engineers of the trust, for they have as often borne testimony to the necessity of such a dyke; but simply the Lords of the Imperial parliament, who, for the mere gratification of one of their number owning the property that bounds the river at that quarter, and whose eyesight would be disturbed by the appearance of said dyke, were it formed, resolutely refuse powers to the Clyde Trustees to construct such a work, and thus entail upon the public all the expense alluded to; upon the shipping trade all the detention and difficulties pointed out; and upon the merchant and passengers, all the disadvantages and drawbacks that may be conceived, but which to enumerate would be a Herculean undertaking.

Talk of the improvements of the Clyde! Let us rather be silent, while contemplating the ease with which a sandbank can be removed compared with a Peer's prejudice.—*Glasgow Advertiser.*

DOVER HARBOUR OF REFUGE.

Divers succeeded on Thursday, the 17th of October, in fishing up out of eighteen feet of water one of the valuable diving bells out of the three that were sunk and employed in the construction of the great packet pier, which, after three years' labour, has been carried out 650 feet into the sea. It is eventually to be carried out 800 feet. None of the masonry of the pier has been injured, but all the travelling cranes and the huge piling were drifted out to sea. Deane, the diver, who was employed on the wreck of the *Royal George*, is to be here to raise the other diving bells, which weigh about five tons each. Mr. Burges, the representative of Mr. Walker, the government engineer, was down to superintend the operations. There are 200 men employed by Messrs. Lee, the contractors, on the works, and it is expected that on all the apparatus being recovered they will resume work in a fortnight. About 700 acres of sea room are to be taken in to make the harbour, and this will occupy another three years. It is now understood, that should most of the machinery and apparatus be recovered uninjured, the damage, which was confined to it alone, and which has been greatly exaggerated, will be under 4000*l.* The diving bell got up is uninjured.

We have received the following from a correspondent at Dover, in addition to the details before given. The late gale has done much damage to the works in progress for the Harbour of Refuge here; and although the masonry is not injured on the new pier, nevertheless the piles are so broken, and the framework used for the diving bells and placing the blocks of stone and concrete are so broken and disarranged, that it will cause great delay in the completion of the western pier; and the loss will be very great to the contractors—not less than 10,000*l.* The beach on the eastern side of the old pier was literally covered with the fragments of piles and timber; and nobody could pass the wreck without contemplating on the awful power of the wind and waves. The sea seems to have torn asunder the large timbers firmly bolted together, as if they were a baby's toy; and judging from the Cob at Lyme Regis, it is pretty clear that if the masonry had been completed a greater distance out in deeper water than it was, that it would have given way and made a break through the 50-feet in width structure. The pier, as far as it has gone, has had a very good effect on the harbour, as it keeps the entrance free of shingle, and it calms the heavy sea that would otherwise make it difficult for a vessel to enter in such a gale. On the other hand, it seems to have a bad effect upon the eastern side of the old pier, as the sea rolls in heavier, and the water has become more shallow, so much so that pilot boats cannot anchor close in as formerly. Much as this grand project of a harbour of refuge at Dover is to be admired, it is still very doubtful how far the plan is good. The anchorage is not good; it is a flat rocky ground; the new work may cause the whole to fill up. Would it not have been a better plan to have selected a place where there was deep water close to, and have excavated a harbour out of fifty acres of the solid earth by means of locomotive engines and machinery?

VICTORIA DOCKS.

The Victoria Docks will occupy a vast tract of land, extending across the marshes in front of the town of Woolwich. One entrance will be in the Gallions, the other in that reach of the river, known by the expressive but not very euphonious title of Bugsley Hole. The main water channel therefore will extend entirely across the marshes, (forming what is now called North Woolwich into an island,) and being nearly three miles in length. The only point at which it will intersect the North Woolwich Railway, will be at a point near Blackwall, where the upper lock will be crossed by the railway, on an incline varying from 1 in 100 to 1 in 200. The breadth of the dock will average about a quarter of a mile, but the limit of deviation extends to double this distance. To afford some idea of the enormous magnitude of this undertaking, it will be sufficient to adduce the comparison used by the projectors of the company. The entire water area occupied by the various docks on the northern and southern banks of the Thames, amounts to 211 acres; the water area of the Victoria docks will extend to 270, being considerably more than the area of all the other docks put together. The number of ships which entered the existing docks, in 1848, was 4,915, with an aggregate of 1,172,707 tons. The Victoria Docks alone will afford accommodation for nearly six thousand vessels, with an aggregate of nearly one million four hundred thousand tons.

The plans of the Victoria Docks are exceedingly comprehensive, and the detail of the arrangements is as perfect as can be conceived. It is the first example of the application of a scientific and well-methodised plan to a great commercial enterprise. The extended plans show three large docks for the accomodation of shipping, as well as a half-tide dock, with one canal, running through the entire line and connecting the four docks together. It is at first proposed to excavate only one dock and the grand canal, leaving the remaining docks to be excavated as necessity shall arise. The first peculiarity to which our attention is directed, is the formation of a double entrance lock, the one of smaller dimensions, adapted for barges, and other small craft; the other much larger and fitted for vessels of the greatest size. This arrangement, which exists in no other docks, has advantages too manifest to be descanted upon. It admits of the exit and entrance of small craft at all times, with the smallest possible loss of water, and the smallest exertion of force. Another grand provision is, the construction throughout all the docks of landing stages, projecting into the water, and enabling a much larger number of vessels to be accommdoated than could be provided for with ordinary quays. On these landing stages, lines of rail with turntables are laid down, so that merchandise can be landed at once from the vessel on to the truck that is to convey it to the metropolis. These lines communicate directly with a line of rails traversing the docks, which in their turn run at once into the main line of the North Woolwich Railway. The cranes and other machinery will be worked by steam power, and attached to to each of the principal docks will be graving docks for the repair of vessels. It is almost impossible to conceive of plans more unique, more comprehensive, or more perfect than those which Mr. Bidder has put forth for these docks.

Up to the present moment, the progress made in the construction of the docks has been confined to the operation of boring, to ascertain the amount of water made by the land springs, in order to provide the engines necessary for keeping the ground clear during the progress of the excavations. The engine has already been purchased, and early in the spring the work of construction will be commenced with great vigour and prosecuted to completion.

ART IN MUNICH.

A great festival of the artists and artisans had been for some time in active preparation, but the unpropitious state of the weather on the 3rd Oct., prevented its full external development. Still the many persons present on this occasion were fully recompensed by the view of one of the chief art-undertakings of the modern German school—we mean the Niebelungen frescoes of Schnorr, on the ground-floor of the New Palace at Munich. It is much to be regretted, however, that the artist has been prevented of late, by a complaint in his eyes, from attending to his work with his usual vigour; still he has been most efficiently assisted by Director Jäger of Leipsic, whom he had already employed in a similar way in the Emperor's Halls of the same palace. The pictures offered to view on the above occasion, were the so-called Saloon of Vengeance, and represent the strife of the Niebelungen with the Huns. The colours of the walls on which they are painted, is scarlet decorated with gold. In the midst of the ceiling are to be seen the prophetic Nereides, in the act of foretelling the events to the hero, whose coats of arms surround the picture. On the minor compartments of the ceiling, Queen Chrimhild is represented calling the warrior Huns to her aid, &c. The lunettes contain four other pictures of similar subjects. We see Hagen, the monk, thrown overboard, as he was to be the only one saved, according to prophetic foresight. The four great pictures on the walls are said to be the best Schnorr ever executed, as for instance the contest on the burning staircase of the palace, a work full of poetical composition and grandeur.

On the 7th Oct., died Charles Schnorr, Professor at the Royal Academy of Arts, thus following soon his friend Rottmann. It is to be regretted, that he has not been able to finish the great picture of the Flood, made by order of King Louis of Bavaria.

The number of fires has been so great last year, that according to a notice of the Minister of Public Works, the income of the Insurance Office, amounting to 944,000fl., is not sufficient to pay the premiums; and an additional per centage is to be levied on the contributories.

ART ON THE RHINE.

The Gothic church of the Minoresses, at Cologne, erected about the year 1220, and consequently coeval with the superb Cathedral, has hitherto been allowed to fall into a state of great decay, as all the care was absorbed by the larger building. It had long been used as an oratory by the Administration of the Poor, but lately surrendered to the Society for the Improvement of Churches. It is one of the finest specimens of pure Gothic architecture, and the restoration has begun by the rebuilding of the lower gallery of the choir, which almost threatened destruction. On the 1st of October an appropriate public festival took place, when the foundation stone for the thorough restoration was laid, which, when completed, will add to the many architectural curiosities of this ancient city on the Rhine.

The south portal of the Cathedral of Cologne has received some additional ornaments in the five statues representing the Saviour and four apostles, which have been placed in the perforated gable. They are from the atelier of the sculptor Mohr, who has also made the ornaments to the cenotaph of Conrad von Hochstitten in the cathedral. The painter, M. Levy Elken, is preparing a new work—the laying of the foundation stone of that edifice, A.D. 1220.

The annual Art Exhibition at Dusseldorf has just concluded, and is considered to have been a very good one. M. Oer's picture, the death of Tasso in the Convent of St. Orafico at Rome, and M. Valkhart's Knox before Mary Queen of Scots, are most praised. In sculpture, nothing worthy of notice has been produced.

Some idea may be formed of the throng of articles which London will experience during the Exhibition of 1851, by the fact that at the Committee-rooms of Dusseldorf on the Rhine, from that single district of Rhenish Prussia, *two hundred and fifty* persons have already inscribed their names as exhibitors.

Berlin.—It is stated that the collection of portraits of celebrated contemporary men of that capital formed by the king in his palace there has been transferred to the Marble Palace at Potsdam. This collection, to be increased from time to time, now contains the portraits of Baron Alexander de Humboldt, MM. de Schelling, Godfrey Schadow and Rauch, Baron Cornelius, Meyerbeer, Louis Tieck, Ritter the geographer, Leopold de Buch the geologist, and Ideler and Bessel the astronomers.—*Athenæum.*

PARIS NOTES.

Road Statistics of Paris and London. — The report of M. Darcy, divisional inspector of the Ponts et Chaussées, who has been to England to obtain information relative to the macadamised roads, has just been published. In this work we find the following particulars relative to the population, extent of the streets, &c. in Paris and London:—The total surface of London is 210 millions of square mètres; its population, 1,924,000; number of houses, 260,000; extent of the streets, 1,126,000 mètres; extent of the streets, not including the foot pavement, 6 millions of mètres; extent of the sewers, 639,000 mètres. The total surface of Paris is 34,379,016 square mètres; population, 1,053,879; number of houses, 20,526; extent of the streets, 425,000 mètres; surface of the streets, exclusive of the foot pavement, 3,600,000 square mètres; length of the sewers, 135,900 mètres; surface of the foot pavement, 888,000 mètres. Thus, in London every inhabitant corresponds to a surface of 100 mètres, at Paris to 34 mètres. In London, the average of inhabitants for each house is 7½; at Paris 34. At London the average of length for each house corresponds to 40m. 40c.; at Paris to a length of street of 15 mètres. These details established the difference which exists between the two cities, from which it appears that there is in London a great extent of surface not built over; that the houses are not very high, and that almost every family has its own. The Boulevards of Paris is the part where the greatest circulation takes place, and the following are the results of the observations of M. Darcy on this subject. On the Boulevard des Capucines there pass every twenty-four hours 9,070 horses drawing carriages; Boulevard des Italiens, 10,750; Boulevard Poissonnière, 7,720; Boulevard St. Denis, 9,609; Boulevard des Filles du Calvaire, 5,856; general average of the above, 8,600. Rue de Faubourg St. Antoine, 4,300; Avenue des Champs-Elysées, 8,959. At London, in Pall Mall, opposite the Queen's Theatre, there pass at least 800 carriages every hour; on London Bridge not less 13,000 every hour. On Westminster Bridge the annual circulation amounts to not less than 8 millions of horses. By this it will be seen that the circulation in Paris does not come up to one-half of what it is in the macadamised streets of London.

Sewerage of Paris.—From the report of M. Darcy, quoted above, it also appears that there are 135,900 yards of sewers in Paris and without the walls, without including 4500 metres of private sewers; most of these sewers are cleaned twice a-week, some only once, and some few require to be visited every day. The number of workmen employed per day is 90, and the expense of the whole service is 122,511f. a-year. The sewers are in a good state, and may be passed through without danger to the health at any time. In the removal of mud, &c., from the streets there are employed every day on an average 345 carts, 523 horses, and 95 asses; the quantity of matter amounts to about 700 cubic yards, and it is conveyed to at least 2000 yards from the Barriers. There are at present 1784 water-plugs, from which water flows three hours a-day to wash the gutters; they give altogether 1784 quarts of water per second, and others are to be established. The streets watered in Paris, including the promenades in the Bois de Boulogne, are 860,000 yards in extent; if all the paved streets were watered the extent would be 3,600,000 yards. The number of water-carts employed is 106; and the expense is 151,876f. a-year. The total cost of the sanitary operations in Paris is 2,663,000f., or 2f. 66c. for each inhabitant.

Security of Bridges in Paris.—A commission of engineers connected with the Board of Roads and Bridges, have examined the suspension bridges of the Invalides, de la Cité, de la Reforme, and de Constantine, by special order. The report speaks of their generally good state of repair, but recommends the making of experiments at the Reforme and Constantine bridges, for testing the solidity of the chains and platforms. An expedient has been recommended, which, if put in practice, will prevent many serious accidents. It consists in the construction of strong gates of iron or timber at the entrance of suspension bridges, and the appointment of special officers whose duty it would be to close these gates, as often as the thronging of too great numbers of people might threaten the rupture of the suspensory chains. It is also projected to erect, in lieu of the present Pont de la Reforme suspension bridge, one of stone; and plans have already been sent in. As the clearing of the space before the Hotel de Ville and the Rue de Châlons are soon to be effected, the providing for the crossing of a greater number of foot passengers and carriages, at this part of the Seine, will have become absolutely necessary.

Improvements in Paris.—The so-called Hôtel de Nantes, which since the time of the Consulate obstructed the fine space between the Tuileries and the Louvre, has at last disappeared, and no more than one week was required for this purpose. With a similar celerity, the structure in the gardens of the Palais Royal has risen out of the ground, which is destined for the exhibition of pictures of living artists.

In the Court-yard of the Palais Royal, a large temporary wooden building is being erected to serve for the next exhibition of modern paintings to be held next December.

Among other large operations is the alteration of the prison of La Force, which is under the direction of M. Gibier, architect, of Paris. It is now completed and being occupied. Being arranged for a house of detention for prisoners waiting for trial, it provides for 1200 cells, in which the inmates can be separately kept. It is said to be the first of the kind tried in France to any extent, In France, separation is enforced before trial; but after conviction. in the jails and the hulks the prisoners are allowed to associate. The arrangements in La Force are taken from the last English, Americo-English, and Netherlandish models; and the contrivances for warming and ventilation are said to ensure perfection.

Among the enterprises now in progress, we may mention the publication of the Encyclopedie d'Architecture, by M. Victor Calliat, architect. It is to include every practical department and detail, as masonry, carpentry, marble-work, iron-work, cabinet-work, plumbing, furniture, &c.; and will be so far of universal use that it will consist chiefly of plates, with very little text. Some of these plates we have seen, and are favourably impressed with the prospects of the work. The work will be a kind of journal, appearing in parts and with illustrations. It will be published on the 1st and 15th of each month; and will contain in each part five engravings. The subscription is about a pound a-year. M. Calliat is the architect who published the magnificent works, the 'Hotel de Ville' and the 'Parallele des Maisons de Paris.'

A railway arcade, similar to that of the Lowther Arcade, in the Strand, is being constructed by the South Eastern Railway Company, on the left hand side of the approach to their terminus on the property in their possession, abutting upon Tooley-street. The design is rather an elegant one, and consists of a succession of shops on either side for the sale of fancy and other articles in requisition by railway travellers, with a large refreshment-room in the centre of the thoroughfare which fronts the railway terminus. The building, between 100 and 200 feet in length, has its basement in Tooley-street, from whence it rises upwards of 60 feet, divided into two stories of 30 feet each, the upper elevation forming the arcade on a level with the railway, and the lower part in Tooley-street forming a range of ordinary shops. There are rooms above the shops, and the floors throughout the building are fire-proof. The front is to be in the Italian style of architecture, and the building, upon which a large number of men have been at work for the last two months, is to be completed and opened by Christmas.

Prussia.—The *Prussian Moniteur* has published a statistical statement of the railway works of that country. from which it appears that 21 undertakings, comprising a length of 364 miles of communication, were open for through traffic in 1849. These railways conveyed 8,597,948 passengers, and 33,313,795 quintals of merchandise. The gross receipts represented 10,782,997 thalers, and the expenses were 5,443,128 thalers, leaving a surplus of 5,339,869 thalers. The capital employed in the construction being 139,740,000 thalers, the return in 1849 was 2·82 per cent. In 1848 the return was stated to have been 3·21 per cent. In 1847 4·32 per cent.; in 1846 4·97 per cent.; in 1845 4·62 per cent., and in 1844 4·74 per cent. The whole of the railways by the works executed in 1849 were augmented by about 20 miles. There are at the present time in progress of construction six other undertakings—namely, the Eastern Railway, those from Westphalia and from Saarbruck, enterprises solely at the government expense, and those from Aix-la-Chapelle to Dusseldorf from Ruhrort Crefeld and to Gladbach, and from Aix-la-Chapelle to Maestricht, constructed by private companies. When these new lines shall have been completed, the whole network of Prussian railways will comprise a length of 440 miles.

Railway Tunnel at Sienna.—Letters from Sienna of the 10th ult. give an account of the inauguration of that section of the Sienna Railway which passes through the tunnel at Monte Arioso, one of the most extraordinary constructions of the kind, due to the talent of the celebrated engineer, Professor Pianigiani. The prefect of Florence, the Royal Commissary of Railways, and Count Serristori, the late minister, were present at the ceremony. The train moved slowly along the tunnel, stopping under the most elevated shafts, before the principal springs of water, and before the spot where flames are seen issuing out of the earth. The train, on leaving the tunnel, was enthusiastically cheered by the numerous spectators who had assembled to witness the scene.

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM SEPTEMBER 26, TO OCTOBER 24, 1850.

Six Months allowed for Enrolment unless otherwise expressed.

James Hamilton, of London, engineer, for improvements in machinery for sawing, boring, and shaping wood.—September 28.

Charles Harratt, of Royal Exchange-buildings, London, merchant, for improvements in rolling iron.—September 28.

Joseph Burch, of Craig Works, Chester, printer, for improvements in printing terry and pile carpets, woollen, silk, and other materials.—September 28.

Joseph Crossley, of Halifax, carpet manufacturer; George Collier, of the same place, mechanic; and James Hudson, of Littleborough, printer, for improvements in printing yarns for, and in weaving carpets and other fabrics.—September 28.

Cyprien Theodore Tissereau of Paris, France, gentleman, for certain improvements in hydraulic clocks.—October 3.

Jean Pierre Paul Amberger, of Paris, France, civil engineer, for certain improvements in the application of magnetic power for moving and stopping carriages, for giving adherence to wheels upon rails, and also for transmitting motion.—October 3.

William Tudor Mabley, of Manchester, patent agent, for certain improvements in the manufacture of soap. (A communication.)—October 3.

William Boggett, of St. Martin's-lane, Middlesex, gentleman, and William Smith, of Margaret-street, in the said county, engineer, for improvements in producing and applying heat, and in engines to be worked by steam or other elastic fluid, which engines are also applicable as pumps.—October 3.

Julian Bernard, of Buchanan-street, Glasgow, artist, for improvements in pneumatic springs, buffers, pumps, and stuffing boxes.—October 3.

Charles Bury, of Salford, Lancaster, manager, for certain improvements in machinery or apparatus for preparing and spinning, doubling or twisting silk waste, cotton, wool, flax, or other fibrous substances.—October 10.

Charles Bury, of Salford, Lancaster, manager, for certain improvements in machinery or apparatus for cleaning, spinning, doubling, and throwing raw silk.—October 10.

Robert Beart, of Godmanchester, for improvements in the manufacture of bricks and tiles.—October 10.

John Scott Russell, of Great George-street, Westminster, engineer, for improvements in the construction of ships or vessels propelled by paddle-wheels, with a view to better arming the same.—October 10.

William Wood, of Over Darwin, Lancashire, carpet manufacturer, for improvements in the manufacture of carpets and other fabrics.—October 10.

William Henry Ritchie, of Kennington, Surrey, gentleman, for certain improvements in machinery for preparing and carding fibrous substances. (A communication.)—October 10.

William Edward Newton, of Chancery-lane, engineer, for improvements in manufacturing yarns. (A communication.)—October 10.

James Hamilton Browne, of the Reform Club, Pall-Mall, Esq., for improvements in the separation and disinfection of fecal matters, and in the apparatus employed therein. (A communication.)—October 10.

William Francis Fernihough, of London, engineer, for improvements in locomotive and other steam engines, and improvements in obtaining motive power.—October 10.

Whiting Hayden, of Windham, Connecticut, United States of America, for an improved regulator or apparatus for regulating the draught of the sliver on the machine, termed the "drawing frame."—October 10.

Ardolf Frederick Gurlt, of Manchester, gentleman, for an improved method of extracting silver from argentiferous minerals.—October 10.

George Michiels, of London, gentleman, for improvements in treating, and preparing potatoes for seed. (A communication.)—October 17.

John Fowler, jun., of Melksham, Wilts, engineer, for improvements in steam-engines, in raising and forcing fluids, in irrigating and draining land, and in machinery for cutting wood for drain-pipes, and other uses.—October 17.

Daniel Trowers Shears, of Bankside, Surrey, copper merchant, for improvements in the manufacture and refining of sugar. (A communication.)—October 17.

John Robert Johnson, of Crawford-street, chemist, for improvements in fixing colours on fabrics made of cotton and other fibre. (A communication.)—October 17.

James Henry Baddeley, of Shelton, Stafford, engineer and designer, for improvements in the manufacture of ornamental articles of earthenware.—October 17.

Thomas Richards Harding, of Lille, France, manufacturer, for improvements in machinery for heckling and carding flax in machinery, for combining and drawing wool and other fibrous materials, and in machinery for making parts of such machines, and for a new arrangement of the steam-engine for driving flax and woollen mills, which arrangement is also applicable to other purposes where motive power is required.—October 17.

Henry Bernoulli Barlow, of Manchester, consulting engineer, for improvements in spinning cotton and other fibrous materials.—October 17.

James Henry Williams, of Birmingham, manufacturer, for certain improvements in the manufacture of buttons.—October 17.

James Young, of Manchester, manufacturing chemist, for improvements in the treatment of certain bituminous mineral substances, and in obtaining products therefrom.—October 17.

Jean Louis Pascal, of Moorgate-street, London, civil engineer, for an improved apparatus for the cure or prevention of smoky chimneys, and also for the ventilation of ships, rooms, and buildings in general.—October 24.

Thomas Beale Browne, of Hampen, near Andoversford, Gloucester, gentleman, for improvements in weaving and preparing fibrous materials, and staining or printing fabrics. (A communication.)—October 24.

Alexander Dixon, of Abercorn Foundry, Paisley, for improvements in moulding iron and other metals.—October 24.

John Mercer, of Oakenshaw, within Clayton-le-Moors, Lancashire, gentleman, for improvements in the preparation of cotton and other fabrics and fibrous materials.—October 24.

John Oliver York, of Boulogne-sur-Mer, France, for improvements in the mode or manner of generating steam in locomotive, marine, and other boilers.—October 24.

John Grant, of Hyde Park-street, Middlesex, for improvements in heating and regulating temperature.—October 24.

Aaron Rose, of Halesowen, Worcester, manufacturer, for a certain new or improved method or certain new or improved methods of manufacturing twisted gun and pistol barrels.—October 24.

Samuel Jacobs, of Highgate Kendall, Westmoreland, cabinet maker, for certain improvements in printing on woollen, cotton, paper, and other substances, parts of which improvements are applicable also to the purposes of colouring, shading, tinting, or varnishing such substances.—October 24.

Bryan Millington, of Brant Broughton, Lincoln, and of the firm of Millington and Sons, of Newark-upon-Trent, Nottingham, millers, for improvements in corn-cleaning and flour dressing machines.—October 24.

Edward Clarence Shepard, of Parliament-street, Westminster, gentleman, for certain improvements in electro-magnetic apparatus, suitable for the production of motive power, of heat, and of light. (A communication.)—October 24.

LECTURES ON THE HISTORY OF ARCHITECTURE,

By Samuel Clegg, Jun., M.I.C.E., F.G.S.

Delivered at the College for General Practical Science, Putney, Surrey.

(PRESIDENT, HIS GRACE THE DUKE OF BUCCLEUCH, K.G.)

Lecture XI.—ROME: *Domestic Architecture.*

It is to be regretted that so little is positively known on the subject of Classical Domestic Architecture. This want of information is however the less surprising, when we consider that the Greeks and Romans were not a domestic people, and that most of their time was spent in public; besides, private residences, however wealthy the community may be, are seldom built with the same solidity as public edifices, and therefore the sooner go to decay. The great changes also that take place in domestic manners, render the habitations of one period unfitted for subsequent times; they are therefore either removed to make way for new dwellings, or so altered as to lose much of their original character: this must have been more especially the case in the great revolution that took place in manners and customs on the spread of Christianity and the dismemberment of the Roman Empire. But notwithstanding the idea of what was necessary and comfortable amongst the ancient Romans differs as widely from ours as does our domestic life from theirs, it is neither uninstructive nor uninteresting to inquire into their mode of living; for as each receding tide leaves some vestige behind it on the shore, so the manners and ideas of past ages have left traces that may be recognised in the present day.

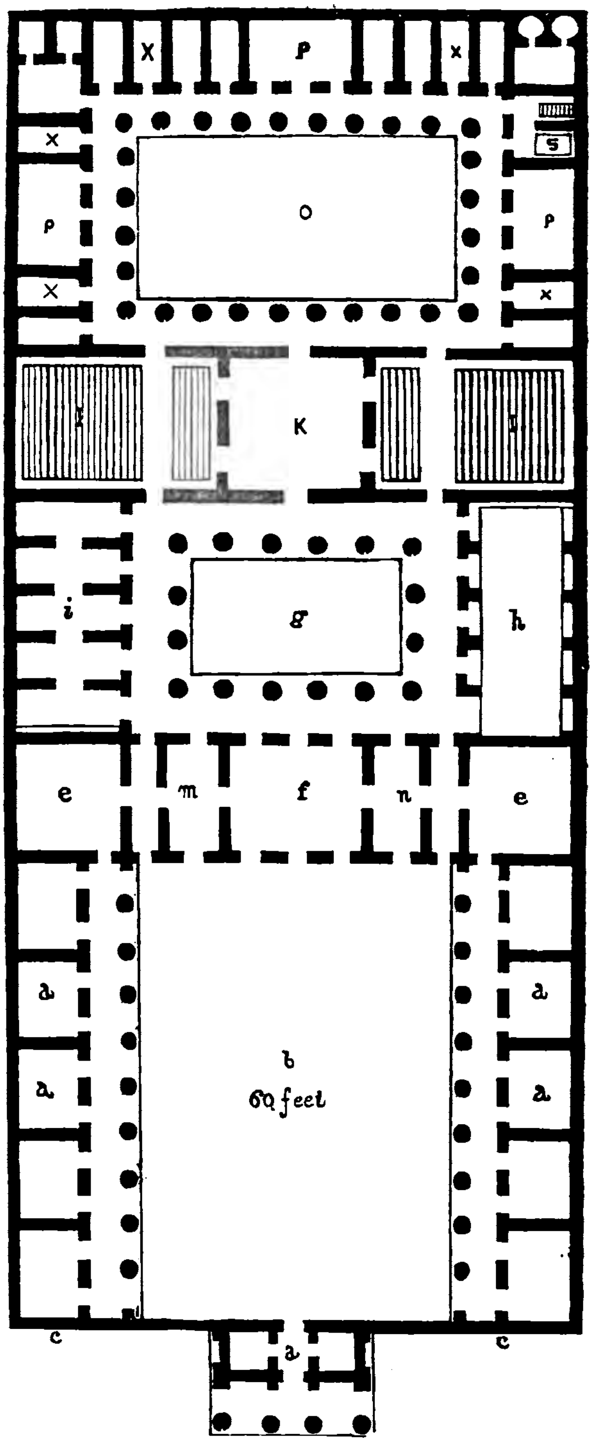
If it had not been for the discovery of Pompeii, we should have been wholly indebted to the descriptions gleaned from various authors for our knowledge of Roman domestic architecture. This little town (buried for 1600 years) played no conspicuous part in history; and had it not been for its singular and unfortunate fate, would probably have utterly sunk into oblivion. The dwelling-houses found there may therefore be supposed to be small and insignificant compared with those of Rome, and other important cities; but still they are doubtless arranged on a similar plan, and prove a great assistance in forming an idea of the private habitations of the Romans, and their style of interior decoration.

For several centuries after the foundation of Rome, the houses were only thatched and covered with shingles; and the laws of the ædiles forbade the walls of private dwellings to be made above eighteen inches in thickness. During the time of the Commonwealth, the Romans were extremely jealous of any attempt made by a citizen to exceed his neighbours in show or style of living. Publius Cornelius Rufinus, though he had been twice consul and once dictator, was removed from the senate on account of the purchase of some silver vases. So little silver was there in Rome at this time, that when an entertainment was given by a senator, the rest of the body were accustomed to lend their plate for the occasion. Lucius Crassus was made to pull down his house on the Palatine Hill, because the roof of the atrium was supported by four columns of foreign marble—an unheard of luxury! It was owing to this atrium, that Brutus used to call him in derision, "the Palatine Venus." Even Julius Cæsar had to obtain permission to construct a pediment to his house, as this was considered a peculiar mark of distinction. Cicero says: "If you could build in heaven, where you have no showers to fear, yet you would never seem to have attained dignity without a pediment."

When Rome ceased to be a republic, all these restrictions were done away with, and the wealthy citizens of Rome seem to have vied with each other in the sumptuousness of their dwellings. The wealth of the world poured into the imperial city; it was no uncommon thing for a Roman patrician to receive as much as was equal to 160,000*l.* per annum from his estates, besides corn, wine, oil, and other produce. Some of these landowners are said to have possessed as many as fourteen villas in different parts of Italy, as well as a mansion in Rome. A favourite site for these luxurious villas was the beautiful shore of the bay of Naples: so splendid were those in the neighbourhood of Baiæ, that when Aristobulus, king of Judea, landed there, he imagined himself already in the capital of the universe.

Rome at one time contained 48,382 houses (including the two classes of insula and domus), ranging from the magnificent palace to the miserable, ill-lighted, and ill-ventilated lodging-house, where the poor congregated. Houses were raised to an inconvenient height, to afford shelter within the walls to the dense population; it was enacted first by Augustus, and afterwards by Nero, that no private house should exceed 70 feet in height from the ground, a law, however, that appears to have been frequently evaded. Many parts of the city were so crowded, that fearful plagues occasionally broke out; a pestilence that occurred in the

Plan of Roman Mansion.



References to Engraving.

a, Vestibulum; *b*, Atrium; *c c*, Alæ; *d d*, Cellæ familiaricæ; *e e*, Courts of the Offices; *f*, Tablinum; *g*, Cavædium; *h*, Exedra; *i*, Bibliotheca; *k*, Cyzicene Occus; *l l*, Gardens; *m*, Pinacotheca; *n*, Rooms for embroidery; *o*, Peristyle; *p*, Vernal triclinium; *q*, Summer triclinium; *r*, Winter triclinium; *s*, Cold bath; *t*, Tepid bath; *v*, Warm bath; *w w*, Sudatories; *x x*, Cubicula.

reign of Titus is said to have carried off 10,000 persons daily. The wealthier classes buying up the land on which to build their mansions, and lay out their extensive pleasure-gardens, ground and consequently house-rent, became enormously dear. In the time of Augustus a single suite of rooms in an insula, or detached house, was valued at 40,000 sesterces, between 300*l.* and 400*l.* per annum. It was intended by Nero, on the rebuilding of Rome, that each house should be an insula; but this was only partially carried into effect.

We know little about the plan or elevation of these mansions: they were probably as varied as in modern buildings. They appear to have been surrounded on three sides by colonnades fronting the streets, and occupied by shops for the sale of the produce of the estate and other commodities; but as trade was considered degrading, the sale was entrusted to freedmen, or slaves, or the shops were let, and brought a considerable rental to the proprietor of the insula. These Roman mansions must have contained a multitude of apartments, as each patrician entertained a train of clients and dependents, besides his servants and slaves. They were built around open courts, like those of the East in the present day, and had few or no windows looking towards the street.

Though, as before observed, the houses were, no doubt, various in plan, it will save confusion in describing the principal courts and chambers they contained, to follow that given by Vitruvius. First, on entering the portico, was the *Vestibulum*, or vestibule; this apartment was generally circular, and derived its name from the goddess Vesta, to whom it was dedicated; it was also sacred to the Lares, whose statues were placed in niches round the wall. Pavements have been found belonging to this part of the house, with the words "*Cave canem*" (beware the dog) formed in mosaic: this might seem to reflect upon the hospitality of the ancient Romans; but the image of a dog barking was generally placed at the foot of the statues of the Lares familiares, to denote their vigilance: the caution, therefore, might be merely a warning against offending the household gods. The Lares were supposed to be the spirits of deceased ancestors, hovering about their former abode for the protection of its inmates; the word is derived from the Etruscan "*lars*"—a leader or conductor. A festival in their honour was celebrated every May, when their statues in the vestibule were crowned with flowers, and offerings of fruit presented.

The vestibule led immediately into the *Atrium*, a large open court or hall, where visitors and clients waited. Atria are said to have been of Etruscan origin, and so called from the city Adria; they were of several kinds. The Tuscan atrium was square, built simply with four beams crossing at right angles, leaving the central space exposed to the air: when the atrium was so large as to require additional support for the beams, four columns were placed at the angles; it was then called tetrastyle. Corinthian atria were generally circular, larger, and more sumptuously adorned: those called testudine were small, and had a vaulted roof something resembling the back of a tortoise, whence their name. The open space in the centre was called compluvium, through which the rain fell into the impluvium, or tank, below; when the rafters were made to incline the contrary way, so as to throw the rain off outside, the atrium was said to be displuviatum. The atrium being the most public part of the house, was always decorated to the extent of the proprietor's means: with fresco paintings representing mythological subjects, or passages from history, and masterpieces from the sculptor's hand. The statues and busts of the family were also placed here, when the master of the house had a right to possess them; but such a privilege was only granted to those who had borne some high office in the state, and was equivalent to a modern coat of arms;—he who had pictures and statues of his ancestors, was accounted noble. Suits of armour, and trophies of war, were also suspended in the atrium. On each side of this court were porticoes or *Alæ*, leading into the *Cellæ familiaricæ*, or apartments for domestic use. It is supposed that in town houses, the *Culina*, or kitchen, with its accompanying offices, was in this division.

Beyond the atrium, and merely divided from it by a curtain that could be raised or lowered at pleasure, was a sitting-room called the *Tablinum*. On each side of this were apartments devoted to embroidery or other work; or perhaps the picture gallery.

Beyond was the *Cavædium*, a smaller court, built in various styles, like the atrium. The cavædium had generally a fountain in the centre, and the compluvium was occasionally covered with a purple awning, tinging the surrounding objects with a warm hue. Some suppose the cavædium to have been merely the central part of the atrium, but in this plan it is represented as a separate division of the house. On one side is the *Bibliotheca*, or library; on the other are *Exhedræ*, or rooms for reading and conversation. The word *theca* signified any kind of repository—thus there was the biblio-theca for books, the pinaco-theca for pictures; the oporo-theca for keeping apples and other fruits; the apo-theca for general stores; and so on. Vitruvius recommends that the bibliotheca should look to the east; because, he says, "books are better preserved when the air and light are received from that quarter: when libraries have a southern or a western aspect, they admit those winds which, at the same time that they carry with them moths, instil also damp vapours into the books, which in process of time cause their decay." Roman libraries were adorned with pictures and busts of eminent literary men, and were furnished with shelves or drawers, where the locumenta or boxes were placed, containing the precious manuscripts: no wonder so much care was taken in their preservation, as a library in those days must have been an expensive luxury, attainable only by the few.

Proceeding onwards from the cavædium, we enter the *Cyzicene occus*, with its surrounding gardens. This saloon must have been a delightful summer apartment, with its large windows looking over the flowery parterres, and open also both to the cavædium and the peristyle. The occi were of several kinds: the tetrastyle, with the ceiling supported by four columns; or the Corinthian, with engaged columns and windows between; or the Egyptian, consisting of two orders. In this last kind of occus, isolated columns supported a second range of engaged columns, having the intervening wall pierced with windows; above all rose the vaulted ceiling ornamented with coffers. These saloons were made lofty to allow of the free circulation of air, so desirable during an Italian summer. Vitruvius directs that the height of all apartments which are longer than they are wide, should be "determined by making it half the sum of the length and width added together; when a square, the height is made greater in proportion by the addition of half the width." Another rule he gives is, "Take a square, one side the width, the diagonal the length; height to the trabes three-fourths the length." The occus was furnished with triclinia, or couches, so arranged that the guests reclining on them might have a full view of the garden.

The *Peristyle* was another large open court, and, as its name denotes, was surrounded by columns: the Villa Gordiana is said to have had a peristyle of two hundred columns. This court was generally planted with trees and shrubs, and sometimes had a fish-pond in the centre: the low wall, or pluteum, connecting the columns, was hollowed out for the purpose of containing soil, in which flowers were planted. When the curtains of the tablinum and the cyzicene occus were raised, the perspective view of a Roman house seen from the vestibule must have been very beautiful; first, the richly ornamented atrium; then, through the tablinum into the cavædium, with its sparkling fountain; and beyond, the sumptuous occus, with the garden of the peristyle terminating the prospect.

Round the peristyle, and communicating with it, were the more private apartments: the vernal, summer, and winter *Triclinia*, or eating-rooms, appropriated to the different seasons, according to their aspect; the *Cubicula*, or sleeping-rooms, small chambers generally containing a recess for a bed, which was laid on a marble tressel, about six inches from the ground;—and the *Baths*, which were considered an essential in every house, and were arranged similarly to the bathing rooms in the public thermæ.

As the principal apartments of the house were always on the ground floor, there was no grand staircase; where there were upper rooms, they seem to have been chiefly devoted to the females of the family, who, however, did not lead so retired a life as that of the Greek ladies: here also were the *Vestiarii*, or wardrobe rooms, and the *Penetralia*, or sanctuary devoted to the penates, or penetrales, as they were sometimes called; these gods were either deified ancestors, or any of the superior divinities, under whose especial protection the house was supposed to exist.

Occasionally a terrace was formed on the flat roof, where the family met to enjoy the prospect and the cool evening breeze; this terrace was shaded by trellis-work, called pergula, and adorned with creepers and boxes planted with flowers: sometimes an aviary added to its attractions. The numerous slaves were lodged in one common chamber underground, called the *Ergastulum*.

In an early stage of civilisation subdivision of labour was almost unknown, and each household had to be in a great measure self-sufficient, all the principal arts and trades being carried on by its different members. Pignorius mentions more than two hundred kinds of employments that were exercised by slaves or servants in the houses of the great. Each mansion contained a carpenter, blacksmith, &c.; and not only the spinning and weaving, brewing, and baking, but building and decorating was the work of the household slaves. Where the floors were so generally constructed of mosaic or tesselated marble, the pavimentarii, or slaves skilful in the art of constructing pavements, must have been necessary members of the family. The floors were frequently laid with small bricks placed obliquely upon their edge, so as to form an angle; a kind of work called *opus spicatum*, because the bricks were placed like the grains in an ear of wheat. Sometimes the brick was mixed with bits of white marble, as may be seen in Pompeii. In the more richly decorated apartments a coating of cement was laid, and upon this, mosaics of elegant design in variously-coloured stones. Occasionally, appropriate inscriptions formed a part of the mosaic floor, such as "*Salve*," and in the bedrooms, "*Bene dormio*." Numerous fine specimens of Roman pavements have been found in every part of their world-wide domain.

In preparing the walls of the rooms for the fresco paintings with which they were decorated, three coats of plaster were used: the first, rough mortar; the second was called arenatum, and was composed of sand and lime, or puzzolano; the third and last coat was called marmoratum, in which pounded marble was used. This was worked and rubbed until a perfectly smooth surface was obtained, and was capable of receiving so high a degree of polish as to reflect objects like polished marble itself. While this marmoratum was still wet, the frescoes were laid on.

The rooms were divided in height by a small cornice, above the door; the upper division being to the lower as two to three. The walls were then divided into compartments, the width of the doorway; these compartments were painted a full deep colour, such as red, cinnamon, dark green, or even black; with the exception of the central medallion, which was occupied by a design in brilliant colours.

The paintings were generally either historical or mythological subjects, or illustrative of passages from the poets; but occasionally landscapes or architectural pieces were introduced; the latter showing a considerable knowledge of perspective. The figure pieces are designed after the manner of bas-reliefs, each figure being independent, without casting shadows one on another: foreshortening was seldom attempted. Occasionally, in smaller compartments, the medallions were brought out in white on an azure ground. Each division or panel was surrounded by a border of elaborate or richly coloured arabesque, displaying an exuberant and graceful fancy. It is difficult to assign an origin to this style of decoration, which the Romans called *ropography* or twig painting: the discovery of the antique frescoes has quite contradicted the idea that it was an invention of the Saracens, or peculiar to Arabian architecture, as the name of arabesque would lead one to suppose. The Romans relied more on the architecture and painting of their rooms, to produce a magnificent effect, than upon the furniture which they contained; upholstery work was almost unknown, as internal decoration was then an art and not a trade.

The art of glazing was evidently known at an early period, as a window of thick greenish glass set in lead, has been found in Pompeii; but this appears for some centuries after to have been an unusual refinement, for Vopiscus mentions glass windows as amongst the luxuries of a wealthy merchant of the name of Firmus, who lived in the reign of Aurelian: a kind of thin stone is described as generally used for windows, called *lapis specularis*, probably talc. Fire-places have occasionally been found amongst Roman remains; but the only chimney appears, in most instances, to have belonged to the kitchen, the rest of the house being heated with hot air.

It is to be supposed that in the various climates through which the Roman empire extended, some variations in the style of domestic building would be found necessary; but none such are discoverable from existing remains.

Of all the splendid palaces erected by the different emperors, few vestiges are left. The Palace of the Cæsars is now only a heap of ruins on the Palatine Hill. The Villa of Hadrian at Tivoli may yet be traced for a circuit of ten Italian miles; it contained theatres, palæstræ, naumachia, thermæ, and every conceivable kind of building for luxury and entertainment. In the library were numerous niches occupied by the finest statues of Grecian workmanship, and a portico near was built in imitation of the Pœcile of Athens. The ruins of this villa have proved an inexhaustible mine from which the cabinets of Rome are still enriched, and some of the most beautiful antique frescoes have been found here.

The Domus Aurea, or golden house of Nero, so called from the gilded tiles of its roof, was built on the borders of an artificial lake between the Palatine and Esquiline hills, and was surrounded by extensive pleasure gardens and porticoes. It is said that the wings of the building were united by a gallery a mile in length. In the interior the walls and ceilings were decorated with gold and mother-of-pearl, or set with precious stones; the ceiling of the great banqueting-hall was painted to resemble the firmament, and so contrived as to have a rotatory motion, and to shower down perfumed water. When this palace was completed, Nero observed, that he had now built a house fit for a gentleman. It did not long remain a monument of his extravagance, for it was partially destroyed by Vespasian, and the Coliseum built on its site.

The only palace of the Roman emperors of which enough is left standing to enable us to trace the plan, and to judge from actual observation of its extent and magnificence, is that of the Emperor Diocletian at Spalatro; commenced A. D. 303. The building occupied twelve years, and, together with the cultivation of his garden, formed the principal amusement of the emperor during his retirement. The plan of this palace is quadrangular, about 700 feet in length by 600 feet in breadth; the walls were flanked by sixteen towers; it was constructed of the beautiful freestone of Tragutium, which is almost as fine in quality as marble: the outer walls are 7 feet in thickness. The building is intersected by two streets at right angles; in the southernmost division were the private apartments of the emperor, and two temples, the one dedicated to Jupiter, the other to Æsculapius, the deities presiding over fortune and health. The former building is now the Duomo of the modern town. It is vaulted, and about 78 feet in height; the dome is constructed in brick-work, and consists of a succession of small arches one over the other, something resembling scales; the roof is covered with tiles, and a floral ornament surmounts the apex: both the temples stood within a temenos. In the great peristyle of the palace, the columns are of granite, and support arches which spring direct from the capital, without any intervening member. The building, though consisting of only one story, was capable of lodging a prætorian cohort. The principal entrance is yet standing, and is still known by the name of the golden gate; over this is a flat arch, composed of indented stones fitting into each other—the first departure from the plain wedge-shaped voussoir. Amongst the decorations in this edifice are seen the rope moulding, and the chevron or zigzag. It is difficult to believe some of the brackets to be of so early a date, so completely do they anticipate the Christian art of after-centuries; especially those supported by the winged head of a child, with the chevron ornament round the mouldings. Few ruins are more interesting than this, as so clearly showing the gradual transition of style.

The country villas of the Romans were in a style of equal magnificence with their town houses; they were divided into three parts: first, the *Prætorium*, or villa urbana, for the residence of the master and his immediate attendants, consisting of the atrienses or household servants, the topiarii or gardeners belonging to the pleasure grounds, the musicians, and the notarius or secretary. Secondly, the *Villa Rustica*, or farm department, where were lodged the procurator or bailiff; the villicus and villica, or husbandman and housekeeper; the master of the cattle; the aviarius or poulterer; and other persons employed on the farm. The third division was called the *Fructuaria*, consisting of storehouses for corn, oil, wine, fruit, &c.

But as much of our information respecting these villas is derived from the writings of Pliny, I cannot do better than make a few extracts from his letter describing his villa at Laurentinum, seventeen miles from Rome:—"My villa, he writes," "is large enough to afford all desirable accommodation, without being extensive. The porch before it is plain, but not mean; through which you enter a portico in the form of the letter D, which includes a small but agreeable area. This affords a very commodious retreat in bad weather, not only as it is inclosed with windows, but particularly as it is sheltered by an extraordinary projection of roof. From the middle of this portico, you pass into an inward court extremely pleasant, and from thence into a handsome hall, which runs out towards the sea; so that when there is a south-west wind, it is gently washed with the waves, which spend themselves at the foot of it. On every side of this hall, there are either folding doors, or windows equally large......On the left-hand side of this hall, somewhat farther from the sea, lies a large drawing-room, and beyond that a second of smaller size, which has one window to the rising, and another to the setting sun......The angle which the projection forms with this drawing-room, retains and increases the warmth of the sun; and hither my family retreat in winter to perform their exercises.......Contiguous to this is a room, forming the segment of a circle, the windows of which are so placed as to receive the sun the whole day; in the walls are contained a set of cases, which contain a collection of such authors whose works can never be read too often. From hence you pass into a bed-chamber through a passage, which being boarded and suspended, as it were, over a stove which runs underneath, tempers the heat which it receives and conveys to all parts of this room. The remainder of this side of the house is appropriated to the use of my slaves and freedmen; but most of the apartments, however, are neat enough to receive any of my friends. In the opposite wing is a room ornamented in very elegant taste; next to which lies another room, which, though large for a parlour, makes but a moderate dining-room......Beyond is a bed-chamber, together with its ante-chamber, the height of which renders it cool in summer, as its being sheltered on all sides from the winds, makes it warm in winter. To this apartment another of the same sort is joined by a common wall. From thence you enter into the grand and spacious cooling room belonging to the bath; from the opposite walls of which, two round basins project, sufficiently large to swim in." He then proceeds to enumerate the different bathing apartments. "At the other end," he continues, "is a second turret, in which is a room that receives the rising and setting sun. Behind this is a large repository, near to which is a gallery of curiosities; and underneath is a spacious dining-room, where the roaring of the sea, even in a storm, is heard but faintly. It looks upon the garden, and gestatio which surrounds the garden. The gestatio is encompassed with a box-tree hedge; and where that is decayed, with rosemary......Between the garden and this gestatio runs a shady plantation of vines, the alley of which is so soft, that you may walk barefoot upon it without injury. The garden is chiefly planted with fig and mulberry trees, to which the soil is favourable, as it is averse to all others. In this place is a banqueting-room, which, though it stands remote from the sea, enjoys a prospect nothing inferior to that view. Two apartments run round the back of it, the windows whereof look upon the entrance of the villa, and into a very pleasant kitchen garden. From hence an inclosed portico extends, which, by its great length, you might suppose erected for the use of the public. It has a range of windows on each side; but on that which looks towards the sea, they are double the number of those next the garden. When the weather is fine and serene, these are all thrown open; but, if it blows, those on the side the wind sets are shut......Before this portico lies a terrace, perfumed with violets, and warmed by the reflection of the sun from the portico......On the upper end of the terrace and portico, stands a detached building in the garden, which I call my favourite; and indeed it is particularly so, having erected it myself. It contains a very warm winter room, one side of which looks upon the terrace, the other has a view of the sea, and both lie exposed to the sun. Through the folding doors, you see the opposite chamber, and from the windows is a prospect of the inclosed portico. On that side next the sea, and opposite to the middle wall, stands a little elegant recess, which, by means of glass doors and a curtain, is either laid open to the adjoining room, or separated from it. It contains a couch and two chairs......Adjoining to this is a bed-chamber, which neither the voice of the servants, the murmuring of the sea, nor even the roaring of a tempest, can reach; not lightning, nor day itself, can penetrate it, unless you open the windows. This profound tranquility is occasioned by a passage which separates the wall of the chamber from that of the garden; and thus by means of that intervening space, every noise is precluded. Annexed to this is a small stove-room, which, by opening a little window, warms the bed-chamber to the degree of heat required. Beyond this lies a chamber and ante-chamber, which enjoy the sun, though obliquely indeed, from the time it rises till the afternoon. When I retire to this garden apartment, I fancy myself a hundred miles from my own house, and take particular pleasure in it at the feast of the Saturnalia, when by the license of that season of festivity, every other part of my villa resounds with the mirth of my domestics: thus I neither interrupt their diversions, nor they my studies. Among the pleasures and conveniences of this situation, there is one disadvantage, and that is the want of a running stream; but this defect is in a great measure supplied by wells, or rather I should call them fountains, for they rise very near the surface."—A healthy situation, good water, and ready access to Rome, either by land or water, were considered indispensable requisites in selecting a site on which to build.

It must be remembered that the villa described by Pliny was merely a winter residence, and of modest proportions compared with those of the more wealthy patricians. Vitruvius says: "Those of the nobles who bear the honours of magistracy, and decide the affairs of the citizens, should have a princely vestibulum, lofty atrium, and ample peristylium, with groves and extensive ambulatories, besides libraries and basilicæ, decorated in a manner similar to the magnificence of public buildings, for in these places both public affairs and private causes are oftentimes determined."

The gestatio, described by Pliny, was a place for horse exercise; the box-trees by which it was bordered were frequently clipped into various forms, like those in an old-fashioned English garden. It was from this custom that the gardeners were called topiarii. The covered and inclosed portico was called crypto-porticus, and was intended for exercise in hot or wet weather; it was what we should call a gallery. A garden apartment devoted to retirement and study, was called a museum, from its being sacred to the muses. Besides the various farm buildings, orchard, kitchen garden, poultry yard, &c., necessary to an extensive country residence, there were belonging to these luxurious villas, warrens for hares and rabbits, and a park planted with forest trees, and containing fish-ponds, and abounding with game of every description. Varro mentions a piece of ground, fifty acres in extent, belonging to Quintus Hortensius, called a theriotrophium, which was devoted to the preservation of wild animals for the chase, such as deer and boars.

The care of the apiary was considered of great importance, and Apicius enumerates snails and dormice as amongst the dishes pleasing to a Roman palate; both of these creatures had places set apart for their nourishment in the villa rustica. When we consider the numerous departments to be attended to, we are scarcely surprised when we hear of three or four hundred slaves being employed on one estate.

We now take our farewell of ancient Rome, with all its magnificence and luxury; and though we may condemn the want of pure taste and inordinate love of ornament, visible in many of the works of Roman architecture, they are at the same time so wonderful in their grandeur and beauty, that every race of architects of every age have approached them not only with admiration but with reverence, as a noble lesson in what the genius of man may achieve.

My next Lecture will be on the Foundation of Constantinople, and the first style of Christian architecture, known as Byzantine.

LIST OF AUTHORITIES.

Vitruvius.—Decline and Fall of the Roman Empire; Gibbon.—Encyclopedie Methodique.—Spalatro; Adam.—Sir J. G. Wilkinson's Dalmatia.—Essay on Roman Villas; Moule.—Pompeiana; Sir William Gell.—Villas of the Ancients; Castell.—Ornaments from Pompeii; Zahn.

APPLICATION OF HIGH ART TO PUBLIC SCULPTURE.

On the Application of High Art to Public Sculpture, and its relation to the wants of the People. By Patric Park, of Edinburgh.

The history of art is progression and retrogression. One bright era, the dynasty of Pericles and Phidias, in the sister arts of architecture and sculpture; another, the bright era of the Cinquecento, in painting, sculpture, and architecture; and a third, the era of the immortal Canova and Flaxman in the resurrection of sculpture in modern times—fill our minds from the works these ages have produced, with the positive knowledge that a lofty perception of the works of God and the high destinies of art were then apparent to artists and recognised by the world—a glorious blaze of sunshine, which seems to have put out the eyes of their successors, doomed to a mournful recognition of past splendour they felt themselves unequal to match or even to confront. Devoid of retrospective ambition, their estimate intellectually of the worth of preceding greatness in art is that which is stamped on the mind of the trader by its marketable and commercial value. No doubt in this the master is acknowledged; but, contemptible sons of great sires, they have lived but to exist on the renown of their fathers—forgetful that past glory forgotten or uncultivated, makes present imbecility a crime, not a misfortune.

Having premised that these remarks were necessary in order to introduce the topic he wished to bring before the public attention—that of recalling to practice a standard in high art, the lecturer proceeded to state, as the principle he wished to enforce, that the use of the *nudo* is the only means by which certain characteristics in man can be illustrated; and that in combination with it, drapery, from its form and infinite variety, is an adjutant principle of scarcely secondary importance in its appeal to human perception, and this not as robes made after a fashion which have their own individual significance, but as a simple covering, taking its immediate style from the genius of the artist, the necessity of the case, and the character of the subject. We advocate these principles

—the use of the *nudo*, and the *nudo* with drapery—not as belonging to any particular age or country, but as being universal in their tendencies, and appreciable of every nation—by all nations—a double power, by which character is not only illustrated to the nation in which it was produced, but in an equal degree to foreigners without the necessity of a translation. Our advocacy of these principles, however, must be precisely understood to be in their application to a high class of character; the application of truth to deformity or malformation would be to the depression not the exaltation of good feeling. It might give opportunity to malignancy; it certainly would be antagonistic to the genius of high art, which reserves itself as the exponent of that exalted personality which rises far above ordinary humanity—such as the hero of a people, the representative of their patriotism—a character sublimed and deified during a lapse of ages, whose example has during these ages fired the generous minded to excel in personal, and to achieve national, distinction,—whose acts were the theme of poets, whose name was the household word of the peasant,—the spell of victory to his countrymen in battle, their shield and spear to sustain them in misfortune—a legacy of worth of character, not honour which would make a man of the same country degenerate. —This class of character the Greeks deified—of these were the demi-gods of the ancients, and to illustrate which no power exists but the *nudo*. Emperors and kings, on the other hand, being different from the nobility of God's creation, are to be represented in their conventional costume, which is unlike an ordinary dress. It is not an uniform; the royal robes of sovereignty are distinctive of an office, differing in different sovereignties, and they stand in lieu of personal superiority, ever but when in those rare instances mind and intellect emancipate the man from the trammels of station, and bring him within the fluctuations of general life to be the benefactor or the scourge of mankind. We meddle not with this section of art: we merely note our recognition of it to prevent mistake as to our meaning elsewhere; neither do we interfere with that class of character to which private or even corporate esteem dedicates statues. The limits of the sphere of operation which have governed that character must determine how far conventionality is to be followed; or, as in the event of grace and beauty being concerned, the true art should be called upon. These being questions secondary to our present object, can ever be safely left to the individual artist, but in whose mind the true principle ought ever to have a fixed station; as the misapplication of a high standard has done already infinite harm, and no doubt has opposed the progress of truth in the public mind, as the visitors to our public monuments in St. Paul's and Westminster can too truly bear witness.

The lecturer then went on to repudiate the principle that sculptors should execute men for their costume, and that a great art should be made a medium for carrying down to posterity a knowledge of the costume of a period. In these details the painter had an advantage which the sculptor did not possess. The sculptor meets the painter in the grand arena; he has nothing to do with secondary art; the very materials he employs are unfit to produce a result in tinsel, colour, embroidery, or texture. He can produce at the best but weak imitation. When necessity compels him, he can carve a chain, but it has no texture or colour; he can imitate by a trick of the chisel the appearance of silk, which demands, however, that the statue have always a layer of dust in his flat effects; he may carve a piece of white lace, for there colour is co-assistant; but in all these he is limited; and the best he does is but an apology, and should never be made much of. Grand folds in drapery are his power; graceful, elegant, and beautiful arrangement, his charm. If he succeeds in that he can afford to want lace on its edges; and if he can model a noble statue *nudo*, he can afford the clothes to the ship figure-head maker. Whenever the sculptor, as he generally does, idealises the costume, by so much does he acknowledge his error in using it at all. When he clings to form, only using a few wrinkles at the knees, ankles, and elbows, he must know that he is neither serving God nor Mammon. Controlled by his employer on one side, and his own aspirations on the other, he produces a work incongruous and unsatisfactory to the very spirit of the age which coerced him.

Mr. Park then pointed out the relation between a true spirit in sculpture and an elevated style of historic painting, referring to the restoration of the Antique in the Cinquecento as the origin of that spirit which produced Michael Angelo and Raphael, and the schools of Florence and Bologna. Whenever the people had their minds familiarised with a high class of sculpture in our public monuments, the painter might prepare his colours, and cheer up his heart with the knowledge that his efforts would be appreciated, and that he would no longer be called upon to paint down to the public taste. Good sense would then be heard reasoning justly on the power of art when it became truthful.

Having argued, in defence of the *nudo*, that the Greeks or Romans did not walk about or fight naked any more than the moderns, but yet that their sculptors, with a just perception of the great in art, adopted the *nudo*, or the *nudo* with drapery, in representing them, Mr. Park contended for the application of the principle in the present day to characters of a high class, in illustration of which he referred to Thorwaldsen's statue of Poniatowsky, in which the *nudo* and drapery are admirably combined; and the statue of Napoleon by Canova, now in the possession of the Duke of Wellington. The treatment of this great statue, he remarked, has subjected Canova to much animadversion, gradually receding, however, in virulence up to the present day, when few will be found to maintain the opinions they may have been anxious to advance twenty years ago. That Canova was right, every day adds its evidence, and ignorance is gradually but surely yielding to the force of true judgment. The imitation of the cocked hat, surtout, and jack-boots, which *illustrate* the Vendome Pillar, is neither that of the man or the hero which will give satisfaction to posterity. Little models of the Parisian statue, glittering in paint, may be seen fulfilling their destiny by giving light to cigar-smokers in tobacconists' shops: never shall we see the heroic figure desecrated to so ignoble a purpose. Future ages will see Canova's work enshrined wherever intellectual power is reverenced, and artistic apprehension of the true and grand is honoured as its exponent. When the Vendome column shall be coined into sous, or re-moulded into its original cannon, the caricature of its art will only facilitate its fall; while, for its great art, Canova's statue must become a treasure to the world. Entirely *nudo* does the sculptor represent the hero, with the addition of an imperial robe hanging from his arm, and which supports the marble. In one hand is held the long rod of empire; the outstretched palm of the other holds the globe and laurel-bestowing victory. The head, modelled from the period of his great Italian campaigns, is full of that beauty immortalised in the medals of the time, and is crowned with laurel. The expression is noble and melancholy, and with it the whole frame is in unison and grace. This statue is the abstraction of the thought and power of an empire—the statue of the Vendome is that of the buffo of the guard-room.

The lecturer then gave a humourous instance of the easy manner in which a person in modern costume might be modelled as compared with the modelling of a figure *nudo* or *nudo* with drapery; and expressed his conviction that to model a man as God made him, and the same man as the tailor and shoemaker make him, requires, in point of time, twelve months for the former to one week for the latter, and in point of skill that of a man to that of a child.

Mr. Park then shortly alluded to the history of the art in Scotland, where, he said, the people hardly knew what a statue meant until about thirty years ago, when Macdonald so honourably to himself produced his heroic models in this city. His era, he characterised as the spark of the flint and steel of the workmen and educated classes in Scotland, and he saw every reason to hope that the fire he kindled was not extinct. The generality of the working classes are yet untainted by dilletantism; they have not to unlearn old prejudices, they are open to receive just impressions, and the lower classes in Scotland have ever shown a quick apprehension of the right and the true. To them principally would he appeal; to the wise and reflective of all classes would he be urgent that the bond of aspiring hopes and love of country should prompt them to leave behind those slow men or those prejudiced men, whose pride prevents improvement. In this question in a remarkable degree, there is a junction of extremes between the higher and lower classes. Both are less artificial than the middle classes. They have less thought on their minds than the money-making portion of the community, who, whatever may be the substratum of their nature, are in the majority, of necessity absorbed in commercial pursuits, and as a class are undivided in the race for wealth, and cannot spare the time necessary to study a subject like art and its relation to nature. The higher and lower classes, again, love nature; both love to look on a man and manly power; athletic exercise is common to both; beauty and grace in the poetry of Burns is felt as deeply by the peasant as the lays of the troubadours were by the knights. The man who admires the boxer out of his lumbering clothes, and can dispute points in his condition, and calculate events from his perfect or imperfect symmetry—who is accustomed to see the brawn and muscle of the stone and hammer thrower, to watch the agility of the racer or the litheness of the vaulter, is a dangerous critic for a nude statue; and the judgment of men like these is favourable to high art, which is thus shown to be eminently fitted for the wants of a large majority of the nation. An additional reason is therefore adduced for exertion by the artists of this country to advocate by word and deed the erection of public works in sculpture of the very highest class, and the selection of pictures of a like superiority for our national galleries.

Mr. Park then referred in very pointed terms to the practice of omitting artists in the nomination of committees of taste, and the selection of individuals little qualified from their pursuits or tastes to decide in such matters. As instances of the doings of such committees, he mentioned the Nelson Monument Committee in London and the Committee for the Monument to Sir R. Peel in Manchester. It appeared, he said, that the Manchester Committee had selected a few eminent sculptors, to compete, giving each fifty pounds for his unsuccessful work, the successful competitor having three thousand guineas placed at his disposal for the completion of the work, the style of costume to be that of the present day. This proceeding he characterised as at once presumptuous in the committee and unjust to art and artists. How dare the members of that committee, he would ask, virtually pronounce that there is no lurking power and talent in their own town, or in their own neighbourhood, or in the nation at large, or in the world, which an open and unlimited competition on the boasted principles of their vaunted political economy might have called forth; to honour and advance art, to adorn their city, and to illustrate the character of Sir Robert Peel. He gladly turned to the example of Salford, and bade the men of Manchester note the different estimate that committee have of their true and just position to their constituents. For the Salford Monument to Peel a competition has been announced also, but open to all the world, the site described, amount of funds advertised, and a date for the reception of designs, leaving the styles free and unfettered to the artistic skill and general knowledge of the competitors. He should not be surprised that Salford, for 1500*l.*, should get a nobler work than Manchester for its 3000*l.*

After some further remarks, the lecturer concluded by calling, in eloquent terms, upon the Scottish public, to show their appreciation of the labours of the artist. He doubted not that it would be found that the late munificence of the Legislature, and the confidence of the country, would be most amply justified by the foundation of a School of Art, which, like our School of Medicine, would be known over the world. Much could be done by art for art; but amid its noble aspirations, the Scottish public must be manly and consistent in that patronage which is the aim of every artist, and the only support of a national school. If the glories of artistic triumph are to add another rose to the National Chaplet, then the nation must be as earnest in its appreciation of the labours of the artist as he will be lavish in sacrificing ease at the shrine of Scottish honour, and for the glory of Scottish Art.

MOTION OF WATER IN PIPES.

On the Motion of Water in Conduit Pipes; on Friction and Pressure in Pipes; and on Jets d'Eau. By M. D'Aubuisson de Voisins, Ingenieur en chef Directeur au Corps Royal des Mines, &c. &c. —(Translated by T. Howard, for the *Civil Engineer and Architect's Journal.*)

(*Continued from page* 165.)

Art. III.—Of the Pressure on the sides of Conduit Pipes.

Having treated of the circumstances attending the motion of water in conduits, let us examine the effects of this motion upon the pressure of the fluid against the sides of the pipes: we shall afterwards point out the most important consequences of these phenomena.

Fig. 5.

26. Let us suppose a horizontal conduit AB fitted to a reservoir kept constantly full. If we close the extremity B, each part of the pipe will experience a pressure measured by the height or head AC; and if at some points H, I, K, &c., taken indiscriminately, we insert vertical tubes, the water will rise in them until the weight of the columns HL, IM, KN, be in equilibrium with the pressure at these points; consequently it will rise in all of them to the level CD.

Let us then open the extremity B; and suppose that the sides of the pipes oppose no resistance to the motion, as in the case of a very short tube, and that there is no contraction at the entrance A. The water will flow in the conduit, and will leave it, with a velocity due to the total head AC. All the force of this head will then act parallel to the axis of the conduit; no action perpendicular to this direction will result from it, and consequently, no pressure on the sides of the pipe; as in the case of water moving in canals, where there is no pressure tending to raise its surface. The fluid in the tubes HL, IM, will sink to the level of the upper part of the water in the conduit.

27. If we only partially unclose the opening B, so that the orifice of discharge be less than the section of the pipe, the phenomena will no longer remain the same. The water will be discharged with a velocity very nearly due to AC; but the velocity in the pipe will be less, following the inverse ratio of the sections. Let v be this lesser velocity, $\cdot 0155v^2$ will be the force or portion of the head AC employed to produce it: still acting on a parallel with the axis, it will exercise no pressure upon the sides. But the remaining portion of the total force, or $H - \cdot 0155v^2$ (by making $AC = H$), acting on all the particles and pervading them in every direction, will press up the fluid from below at I, K, &c., and it will ascend in the vertical tubes to a height equal to $H - \cdot 0155v^2$; which will be limited by the horizontal EF, CE being equal to $\cdot 0155v^2$. Hence comes the great principle which Bernouilli has established by calculation, confirmed by experiment, and which he has made the basis of his Hydraulic Statistics ('Hydrodynamica,' Sectio XII.); namely: *the pressure which water running in pipes exercises upon any given point of its sides, is equal to the effective head on that point, minus the head due to the velocity in the pipe.*

28. The resistance which the sides of the pipes oppose to the motion, does not in any way weaken this principle; it only diminishes H, or the head which without it we should have had upon the point under consideration. Let us examine this in detail.

This resistance is proportional to the length of the conduit (4); that is, to the length of the journey made by the water; thus, in the same conduit it will go on progressively increasing from its origin A, where it is nothing, to its extremity B where it is $\cdot 00071 \frac{LQ^2}{D^5}$ (7.) So that if on BD we take FG, equal to this expression, as representing the resistance at B; and draw the line EG, the resistances at H, I, K, &c., will be represented by the lines ae, $a'e'$, $a''e''$, &c. (since $ae : a'e' : a''e'' : \ldots\ldots FG :: Ee : Ee' : Ee'' \ldots\ldots EF$). Let us designate these resistances by $r, r', r'', \ldots\ldots R$. At each of the points we have indicated—at I for example—the column MI, the index of the pressure in a state of repose, will sink: 1st, from Me ($= \cdot 0155v^2$); for in this case as in the foregoing, this portion of the motive force, being directed in a line with the axis of the conduit, will cause no pressure on the sides. 2nd, from $a'e'$ ($= r'$); this other part of the total force having been absorbed, and as it were destroyed, by the resistance from friction between R and I, could no longer have any action on this last point: the pressure there will be measured simply by $a'I = H - r' - \cdot 0155v^2$. In general, the pressure at any given point of a horizontal conduit, where r represents the resistance met with from the beginning, is expressed by $H - r - \cdot 0155v^2$.

At the extremity of the conduit where the resistance is R, the pressure $GB = H - R - 0155\ v^2$. If this extremity were quite open, we should have (2) $R = H - \cdot 0155\ v^2$, and consequently $GB = 0$; that is to say. that the pressure of the extremity of the conduit would be nil, and that the columns increasing the pressure at its various points will have the line EB for their highest limit.

29. Let us consider finally the case of an ordinary conduit, that is, of a conduit inclined and having the extremity only partially open. In a state of repose, the columns indicating the pressure will be raised to the horizontal CD, the level of the fluid in the reservoir, according to the Hydrostatical law of *Communicating Tubes*: they, and consequently the pressures, will be unequal; each will have for measure the difference of level between the point where it is exercised and the surface of the reservoir. When the fluid is in a state of motion, these columns will undergo the same

diminutions as in the preceding number, and by reason of the same causes; their summits will only reach the line EG, which will be their limit (they would be limited by EB, if the conduit were quite open); consequently, the pressure upon any one point of which H_0 is the depression below the reservoir, will be expressed by $H_0 - r - {\cdot}0155\, v^2$.

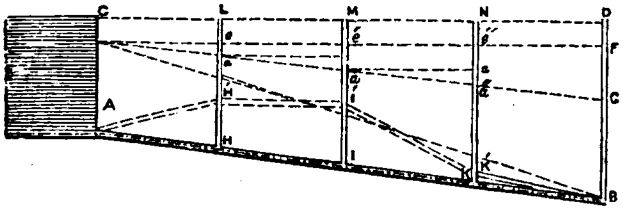


Fig. 6.

The expression will be the same for an undulating conduit as AH' I' K' B; only the summits of the columns will no longer be in a right line; the resistances, being proportional to the length of the pipes, will strictly follow the ratios of AH', AI'; but not those of E e, E e'; a condition necessary in order that the points A, a, a', may be in a right line.

Total Head; and Effective Head.

30. We have called the *head of a conduit*, and designated by H, the difference of level between the surface of the fluid in the reservoir, and the orifice of discharge; it would be the height due to the velocity of discharge, if the pipes offered no resistance to the motion. But the resistance diminishes this *entire head*, so that the *effective head* of the conduit, or the height by virtue of which in reality the fluid runs out, will be less according to the resistance which it will have met with, from the beginning to the extreme end of the pipes; R being that resistance, the effective head will be H — R.

By analogy, for every point of the conduit, its *total head* will be the height of the reservoir H_0 above it; and its *effective head* will be this same height diminished by the resistance experienced by fluid from the origin of the conduit to it, or $H_0 - r$.

Difference between the Head and the Pressure.

31. Since the pressure upon this same point is $H_0 - r - {\cdot}0155\, v^2$, ${\cdot}0155 v^2$ will be the difference between it and the head. In general, the height due to the velocity of the water at any point of a conduit, is the difference which exists there between the effective head, or the head properly so called, and the pressure upon this point. It is not correct to take one for the other; but in large conduits, where the height due to the velocity is very small, the error is seldom or never of consequence.

Of the Piézomètre and its Indications.

32. The guage tubes which we have supposed to be placed on the conduits, (and which, by the height to which the fluid is raised in them, measure the pressure which exists at the points to which they are fitted,) have been named in France, Piézomètres (*piesis*, *pieseos*, pressure; and *metron*, a measure).

They serve to give us as it were a physical representation of what is understood by *resistance* and loss of head. Let us suppose that we have fitted one upon a given point of a conduit situated at H_0 below the level of the reservoir. According to what has just been said, if the water were in repose in the conduit, it would rise in the tube to the height H_0; when the water is running it will sink, and remain at the height $H_0 - r - h$, h being the elevation due to the velocity v. The depression, or the difference between the two heights will be then, $H_0 - H_0 + r + h$; and in designating it by x, we shall have $x = r + h$; or, $r = x - h$; that is to say, *the resistance experienced by the water, from the origin of the conduit, to any point of its length, will be represented by the difference of level between the surface of the reservoir and the summit of the fluid column in a piezometer fitted upon this point* (*minus the height due to the velocity in the conduit*, a quantity always very small). If we augment or diminish the volume of water running in the conduit, and consequently its velocity, by enlarging or contracting the orifice of discharge, the fluid in the piezometer will become lower or higher, in a slight degree, very nearly proportional to the square of this volume or velocity.

$$\left\{ \text{The depression ought to be } Q^2 \left({\cdot}00068 \frac{L}{D^5} - \frac{{\cdot}02512}{D^4} \right) + Q \frac{{\cdot}000096 L}{D^3} \right\}$$

and we shall have to compare the results of theory with those of experiment.

For a second point of the conduit, taken, for example, lower down stream than the first, we should have in like manner $r' = x' - h$, since the velocity of the height due to it, h, remain the same throughout the conduit. Cutting off from this equation the first $r = x - h$, we have $r' - r = x' - x$. Now, $r' - r$, the difference between the two resistances, is evidently the resistance met with from the first point to the second; and $x' - x$, the difference between the depression of the two piezometrical columns below the reservoir, will be the difference of level between the summits of the two columns; thus, *the resistance which the water meets with from one point of a conduit to another, or the loss of head from the first to the second, is indicated by the difference of level between the summits of the fluid columns of two piezometers, fixed one on each of the two points.* If the diameter of the pipe on which the second piezometer is fixed were different to the first, then the height h' due to its velocity would no longer be equal to h, and we should have—

$$r' - r' = x' - h' - (x - h) = (x' - x) - (h' - h);$$

that is, the resistance from one point to another would be measured by the difference of level between the two piezometrical summits, minus or plus the difference between the two heights due to the respective velocities, according as the velocity at the point down stream should be greater or less than the other.

We see, by these examples, how the piezometer renders perfectly clear the resistance in pipes, and the variations which take place in them; and, consequently, how useful its indications may be. I have such an instrument, made of glass, fixed on one of the conduits of Toulouse, and carried into the office of the engineer of these works; and it indicates to him constantly the state of the water, and the disturbances it meets with.

Thickness required for Conduit Pipes.

33. [Under this head, D'Aubuisson discusses the theory of the force of pressure tending to burst a conduit pipe; and then from the results of experiment on the cohesive strength of cast-iron, deduces the thickness of pipe necessary for various diameters to withstand this pressure. Adding to this theoretical value, a margin to allow for the sudden shocks to which conduit pipes are liable, and for the imperfections usual in castings, the formulæ which he finally submits and has adopted for practice is, calling thickness of pipe e,

$$e \text{ in inches} = {\cdot}394 \text{ ins} + {\cdot}015 \text{ dia. in inches.}$$

For pipes of less than 4½ inches diameter, he considers there is no necessity to add the second term of the equation, but makes them all about ⅜-inch in thickness.

This formulæ is for pipes proved to ten atmospheres, or about 300 feet head.]

Art. IV.—Of Systems of Conduits.

It is rare in practice that we have to deal with a simple conduit, conveying to its extreme end all the water it receives at its origin. A portion of this is generally carried off, at various points, by secondary conduits; from these again branch pipes of a third order, so that a large distribution of water in a city or town, presents as it were a trunk branched and sub-branched in every direction.

34. To determine the circumstances of the motion of water in the different parts of such a system, and that by the knowledge alone of the dimensions and respective position of the several parts, is a complicated problem, of which a solution has not yet been given; and yet the calculations which an engineer has to make relate generally to a system, and not to an isolated conduit.

To form an idea of the basis on which I have established the solution that I am about to give, and which is applicable to at least some cases, let us suppose a system already existing, adapted to a reservoir maintained constantly full, and discharging water through mouths at the end of various branches. Let the question to be determined be, for instance, the quantity of water flowing out of each mouth (although that is not the object we have now in view), it is evident that we could immediately calculate this quantity if we knew the *effective* head of water at the end of the branch, that head of water being the height due to the velocity of discharge (30). But after what has been said (30—32) the effective head is the entire head, minus the loss of head or resistance that the fluid has experienced in its passage through the system from the reservoir to this mouth; so that this problem is reduced to the determination of the amount of the several losses of head.

Of the Several Losses of Head.

35. These arise, 1st, and almost solely, from the frictional resistance of the sides of the pipe. 2ndly. From the resistance due to the bends. 3rdly. From the change of direction in the movement

when the water passes from the main conduit into a branch, and from a branch into a sub-branch. 4thly. From eddies occasioned by the diversion of the water at the head of each branch or sub-branch. As to the resistance arising from contraction, it is unnecessary to take it into account; we should not admit a permanent contraction in a conduit: if one accidentally exists we have pointed out the method of calculating its effect (20.) We have seen (15) that all resistance to the motion of water in a conduit pipe is an effort opposed to the motive force or total head, and which absorbing a part of it, causes a loss of head.

We have treated in detail the first two of the four losses that have just been pointed out, and shall now limit ourselves to the recapitulation of them.—The equation for the resistance of the sides (6) is

$$= \cdot 000677 L \left(\frac{Q^2}{D^5} + \frac{\cdot 1417 Q}{D^4}\right).$$

For the resistance from bends (17)

$$= \cdot 00608 \frac{Q^2}{D^4} \sin^2;$$

The other two remain to be examined.

Loss of Head arising from Changes of Direction.

36. When a body moving with a velocity v in one direction, is forcibly turned in another, making an angle i with the first, its velocity is then only $v \cos i$. In the same way, when a fluid in a conduit having a velocity v, passes into a branch, obstructing the other forces which may act upon it, it will then only have the velocity $v \cos i$. The force or head due, which was $\cdot 0155\, v^2$ in the conduit, will only be $\cdot 0155\, v^2 \cos^2 i$; it will then have lost in head $\cdot 0155\, v^2 (1 - \cos^2 i)$, or $\cdot 0155\, v^2 \sin^2 i$.

Almost all branches are made at right angles to the main conduit, although they afterwards be diverted by greater or less bends. In this case $i = 90°$, $\sin i = 1$, and the loss of head, recollecting that $v = 1\cdot 273 \frac{Q}{D^2}$, is $\cdot 0252 \frac{Q^2}{D^4}$; that is to say, the head or force due to the velocity that the water has in the main conduit is entirely lost: it has no effect in the direction of the branch: the fluid only enters this by virtue of the pressure (or piézomètric height) existing in the conduit at the point of junction.

Loss due to Erogation.

37. At this junction there will be yet another loss of head. In order to measure its amount MM. Mallet and Yénieys, engineers of the Paris Water Works, placed a piézomètre on a conduit 9⅘ in. diameter, a little above the junction of a branch of 3⅓ in. diameter; and they placed a second guage a little way down this branch. The water stood in this last ·39 feet lower than in the first, the quantity discharged through the branch being ·1535 cubic feet per second; the velocity was 2·778 feet, and the head due to that velocity ·120 feet: this last quantity should be taken above the elevation of the first piézomètre to impart the above mentioned velocity, there will then remain only as the difference, or for the effect of erogation, ·274 feet, a quantity 2·28 times greater than that due to the height. The discharge from the branch being increased to 35·4 cubic feet, the difference between the two piézomètres was ·502 feet; the height due to the velocity being then ·168 feet; and there remained for erogation a quantity 1·94 times greater than that height. We conclude from these experiments that the loss of head occasioned by erogation is equal to about twice the height due to the velocity in the branch.

Any uncertainty as to the amount of the loss of head due to erogation, as well as those arising from bends and change of direction, does not involve any practical consequence, these values being so slight relatively to the others which enter into the equations, especially to the loss resulting from the action of the sides, and the latter has been determined by the aid of more than fifty experiments.

38. For some time I feared that the erogations for the branches might extend their effect to the conduit itself, below the points of junction, and that the bend might experience a considerable diminution. If it had been so, the solution of the problem which I give here, and which I had implicitly given in my '*Traité sur le mouvement de l'eau dans les Conduites*, 1827,' would have been completely defective. To decide this important question, I instituted the following experiments in 1830:—

On a conduit 3⅓-inch diameter, 2090 feet long, I had placed at 1414 feet from its commencement, a tube having a cock through which we could let off a greater or less quantity of water; this represented the circumstances of a junction. At 1·64 feet above, as well as at 2·30 feet below, we fixed a large piézomètre; the head of water on the conduit remained nearly constant,) 24·28 feet, and its extremity was quite open. We discharged through the junction the volumes of water indicated in the margin, and have noted opposite those which flowed from the extremity, as well as the height at which the water stood in each of the two piézomètres. As we could not determine the heights within about ⅛ of an inch, we may conclude they were the same above and below the point of junction. This equality of pressure was maintained in several other experiments that I made with the same apparatus.

Water discharged in One Second,		Piézomètre.	
At the Junction.	At the end of the Conduit.	Above.	Below.
Cubic feet.	Cubic feet.	Feet.	Feet.
·000000	·059860	6·23	6·27
·009479	·052656	4·99	4·99
·029494	·036058	2·98	3·05
·046250	·020448	0·59	0·56
·048736	·018152	0·39	0·33

Thus a branch made in a conduit does not sensibly diminish the pressure or bend below the point of junction; and in a system of conduits, we may consider that there are no other losses of head but the four in question.

Final Equation for the Motion in a Branch.

39. Let n be a branch or sub-branch of any order whatever, supposed to be quite open at the end. Again, let

d_n be the diameter of such aperture at the end.

m_n the coefficient for contraction.

H_n the entire head of the branch, or the difference of level between surface of the reservoir and the orifice of discharge.

D_n the diameter of the branch.

L_n its length.

Q_n the quantity of water it conveys.

S^2_n the sum of the squares of the sines of the angles of reflection at the various bends.

[R] the sum of the resistances or losses of head experienced by the water which flows in the branch down to its junction.

If, by following the course of the water which reaches it, we represent by r and r' the losses of head due to friction and bends upon the main conduit as far as the first branch; by r_1, r'_1, r''_1, r'''_1, the four losses of head upon this first branch; by r_2, r'_2, r''_2, r'''_2, the four losses of head upon the second up to the third branch; and so on successively up to the branch $n-1$, to which is adapted the branch n, we shall have—

$$[R] = r + r' + r_1 + r'_1 + r''_1 + r'''_1 + \ldots\ldots r_{n-1} + r'_{n-1} + r''_{n-1} + r'''_{n-1},$$

since the sum of the losses of head, deducted from the total head, gives the head due to the velocity of discharge (34); or, rather. the entire head is equal to the sum of the losses plus the head due to the velocity of discharge, which is (13) $\cdot 0252 \frac{Q^2_n}{m^2_n\, d^4_n}$, and the equation will be

$$H_n = [R] + \cdot 0252 \frac{Q^2_{n-1}}{D^4_{n-1}} + \cdot 000677 L \left(\frac{Q^2_n}{D^5_n} + \frac{\cdot 1417\, Q_n}{D^4_n}\right) +$$

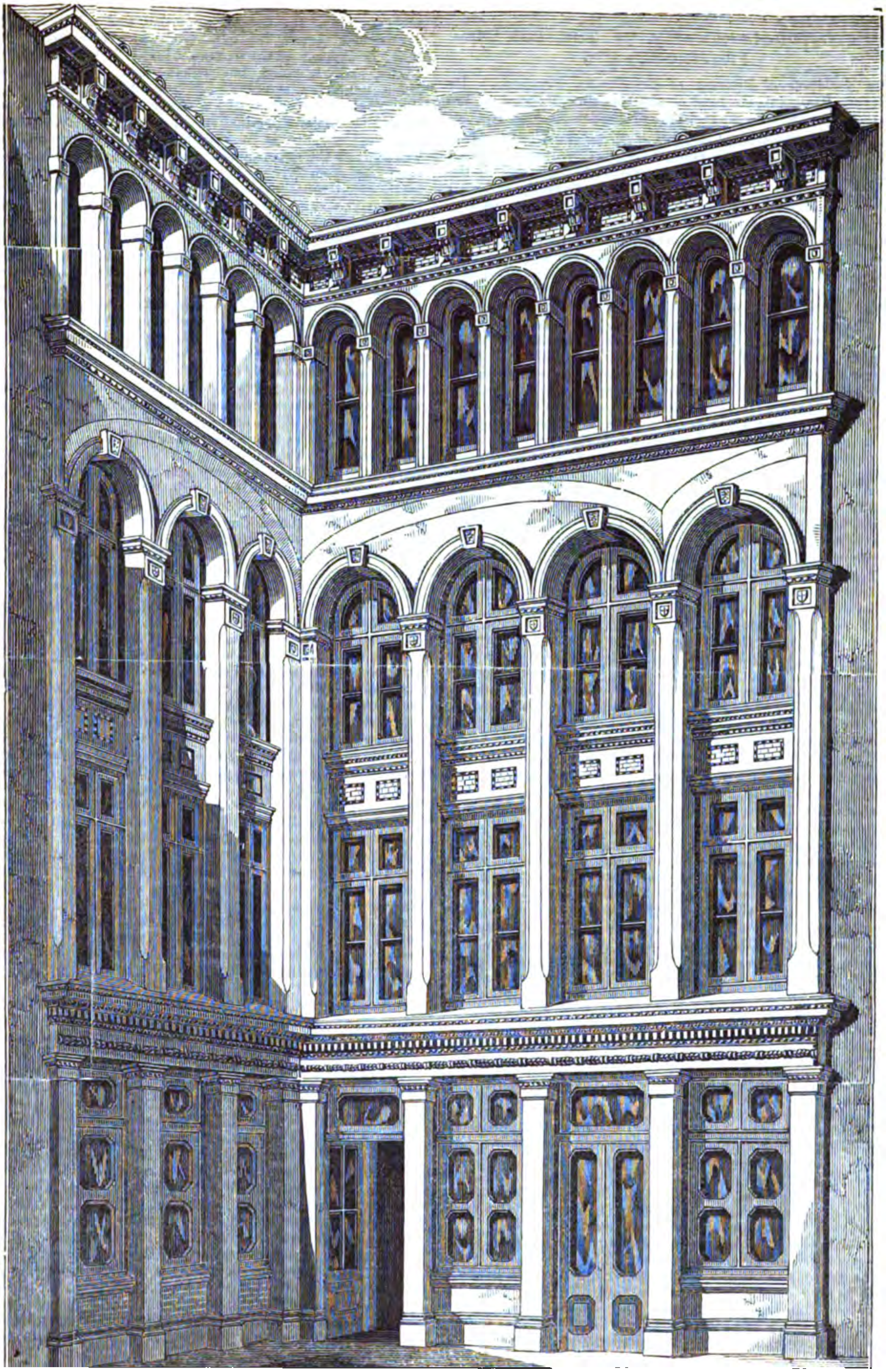
$$\cdot 0061 \frac{Q^2_n}{D^4_n} \cdot \int_n^2 + \cdot 165 \frac{Q^2_n}{D^4_n} + \cdot 0252 \frac{Q^2_n}{m^2_n\, d^4_n}.$$

When the branch is entirely open at its extremity, $m^2_n\, d^4_n = D^4_n$.

The above equation enables us to determine, directly or indirectly, either of the values implied in it, from a knowledge of the others.

ADELAIDE CHAMBERS, GRACECHURCH STREET.

The engraving we now give represents some chambers and buildings around what many would make into a common alley. Mr. Charles Corbett, architect of this design, has, however, without any ambitious attempt to carry out a costly structure, created a picturesque composition, of which there are few examples of the same kind in the City. The shape of the ground and opening seemed unfavourable to any harmony of design; but as now arranged, and by the treatment of the walls, a very pleasing effect is produced. We think this endeavour very praiseworthy; and though we may differ as to details, we think the example well worthy of being adopted in many situations in the City, where the only unity is the correspondence of square windows, and the only simplicity that of brick walls.



ARCHITECTURAL REMAINS OF THE ROMAN PROVINCES.

On the Architectural Remains of the Roman Provinces. By JAMES BELL, Esq.—(Paper read at the Opening Meeting of the Session 1850-51 of the Royal Institute of British Architects.)

ALTHOUGH the architectural remains of Rome and Italy in general have been thoroughly investigated, there is reason to reflect that other parts of the extensive empire of the Mistress of the World have not received the attention they deserve; and that while there is no doubt that a perfect and correct taste is only to be acquired by a study of the best works, it should not be forgotten that many remains of inferior artistic merit may yet present varieties of form and idea deserving of attentive consideration. The more complete our knowledge is of the whole scope of ancient art, the more likely are we to be correct in attempting to realise a just conception of the original nature of the best works, many of which are now in so hopeless a state of ruin. The student, therefore, might do well to add to his examination of the remains of the Eternal City itself, that of some of the Roman provincial towns, which the want perhaps of a correct appreciation of the character of that people has hitherto caused to be, in great part, neglected.

Nothing marks more strongly this character in the later ages of the Republic and during the rise of the Empire, than the method pursued by them in dealing with surrounding nations. They had no desire for allies and tributaries; their treaties were hollow and treacherous, intended to be broken on the first opportunity, conquest being their only aim,—not with the view of obtaining subjects, but in order that each nation should in turn be incorporated with Rome, and form an integral part of the great empire. For this reason, submission was quickly rewarded with freedom and every Roman privilege, while resistance was punished to the last extremity. We should therefore naturally conclude, that evidence would be found in the monumental records of the provinces of Rome, of this identity with the mother country—and this we find to be the case. Germany, France, Spain, Africa, Egypt, and Palestine, all contain specimens of greater or less magnificence and grandeur, many in a high state of preservation, and some possessing peculiarities of form, construction, and arrangement, which render them highly interesting and valuable. I shall endeavour to call attention to some of the most important of these monuments, and to show that correctly measured representations of them deserve a place on our shelves, by the side of the illustrated works by Stuart and Revett, and by Taylor and Cresy.

Omitting all allusion at the present time to the underground remains which abound in this country and elsewhere, as well as to the roads and fortresses, which belong rather to engineering than architecture, we need not go far to find some monuments of considerable importance. The Porta Nigra at Treves is a stupendous work — two towers, 90 German feet in height, and more than 30 feet in diameter, and decorated with four orders of columns, are united by a curtain, 55 feet in extent, and three stories high, in which are the two gates; excepting the lower story, the whole is also arcaded. This design of a gateway is unique, and it exceeds in dimensions any similar building elsewhere. Treves possesses also the remains of an amphitheatre, in which some peculiarities of the substructure are apparent,—also those of a basilica; but next to the gate, the monument of Igel is the most curious, and may be compared with one of a similar description at St. Remi in the south of France. There was also a monument of a similar description at Arlon, but the ornaments were transported in the 16th century by the Count de Mansfeldt, to form part of a collection of antiquities long since dispersed: that of Igel was happily preserved from the same fate. Had these monuments attracted the attention they deserve, some better idea could now be given than a mere verbal description. It was one inevitable consequence of the Roman policy before described, that all remains of a former civilisation were inevitably obliterated, but there are strong reasons for supposing that this neighbourhood was very far from being in a state of barbarism before the Roman conquest. We may believe this without going back to the early foundation of Treves claimed by some historians.

But it is in the south of France that we can more completely form a correct idea of a Roman province. This portion of France formed the province of Gallia Narbonensis, having been subdued from one to two centuries before the Christian era. Here the arches, gates, temples, amphitheatres, and aqueducts, rival those of Rome itself, which possesses no temple of the kind so perfect as the Maison Carrée, at Nismes. This edifice is a hexastyle prostyle temple of the Corinthian order, and originally stood in the centre of a forum, the extent of which has been traced by the bases of several of the columns found *in situ*. The Temple of Diana, as it is called, but which was in reality the Hall of the Baths, exhibits a beautiful arrangement of pilasters and niches in the interior, connected with a shrine in the centre of one end, of great elegance and originality. The amphitheatre, though smaller than the Coliseum, is in a far better state of preservation. This was built at the expense of Antoninus Pius, whose ancestors came originally from Nismes, and the Maison Carrée was dedicated to his adopted sons, Lucius and Marcus. It will be seen from the plan of the amphitheatre, that it is constructed somewhat differently from the Coliseum. We can here study the preparations for the velarium; the arrangements of the seats, galleries, and staircases. The podium round the interior is formed of single stones, 5 feet in height, to retain the water for the purposes of the naumachia.

The antiquities of Arles consist of an amphitheatre, a theatre with two columns of the proscenium still standing; and innumerable tombs and sarcophagi. Orange possesses a theatre of the most gigantic dimensions; the seats are cut out of the side of a hill, and the scene wall rises to a height of more than 100 feet by 300 feet in length. Though the marble decorations are, as in many other instances, almost entirely gone, it is still a most interesting relique. There are also several arches remaining of the hippodrome, and a beautiful triumphal arch in a very fair state of preservation. The ornaments have suffered from the singular purpose to which the building was appropriated by the Princes of Orange—when it was built into the Chateau, and the archway formed the principal *salle de reception*. The portion of the Roman aqueduct, now called the Pont du Gard, is too well known to require a detailed description.

The monopteral monument at St. Remi is of most beautiful design and proportions, and well deserves study as a model of this description of edifice. The gates of Nismes, Besançon, Sens, and Saintes, between La Rochelle and Bordeaux; the amphitheatre, aqueduct, and the Porte Dorée at Frejus, the birth-place of Agricola; the arches at St. Remi and Carpentras; the bridge and arches at St. Chamas, between Arles and Marseilles; and the innumerable fragments collected in the museums of Nismes, Arles, Avignon, Narbonne, and Toulouse, offer to the student who wishes to become acquainted with Roman art in the time of the Antonines, the strongest temptations to be found within the range of a summer excursion.

Spain offers an example no less striking of the peculiar character and vicissitudes of a Roman province. All vestiges of early civilisation previous to its subjugation are gone, and in its place we find most extensive remains of Roman enterprise and constructive skill, of which it is much to be desired that we possessed more detailed and illustrated descriptions than those which are at present within our reach. We learn, however, from the hand-book, that there is a Roman bridge at Merida, 2575 feet long, besides numerous antiquities, among which is a peripteral temple. At Alcantara is a bridge of Trajan, 600 feet long, and 245 feet above the usual level of the river. At La Barca five arches remain of a Roman bridge; the same at Capara; at Toledo there is a temple; near Tarragona a superb aqueduct, and a monument called the tomb of the Scipios, and at Segovia an aqueduct, 2500 feet long.

Passing now to Africa, we find that the same destruction of previous evidences of civilisation took place here as in other colonies. All that remains of Punic Carthage are a few inscriptions occasionally dug up: everything else is Rman. The best illustrations we have of these ruins are contained in two volumes of drawings by Bruce the African traveller, which are now in the royal collection at Windsor. Besides the usual amount of triumphal arches, some of which are of forms not elsewhere met with, there are other buildings of an unusual description. Of the first class is one large square inclosure at Suffetala, entered by a large triumphal arch, and containing three Corinthian tetrastyle temples connected together. At Lambessa a building, something in the form of a basilica, now roofless, entered on each of the four sides by a large centre arch, with two small ones flanking it; two orders of engaged columns, with broken entablatures, forming the exterior decoration. At Thisdrus, a very fine amphitheatre, approaching the Coliseum in size, and even surpassing it in state of preservation. At Tripoli, an arch of the time of the Antonines. Considering the Cyrenaica as a Greek colony rather than a Roman province, we may omit a detailed description of the remains, which, we are informed by Captain Beechey, consist of sculpture of the best style, with tombs, pavements, theatres, amphitheatres, and city walls, very perfect. Greece and her colonies, as well as Egypt, formed some exceptions to the usual routine of Roman conquest—Grecian civilisation acquired the respect even of the imperious Roman, and severity was only exercised towards the Grecian race, when provoked by imprudent resistance. Egypt also wisely submitted —Ptolemy bequeathed his kingdom as a legacy to the Roman republic, but the Egyptians kept aloof as much as possible from Rome; and while they avoided disputes, they equally renounced a participation in the honours of a close connection with the people who had overthrown the empire of the Pharoahs, and it is not till the third century of our era, that we find natives of Egypt accepting office under the empire. We may thus account for finding remains of Grecian civilisation in Cyrene, and of Egyptian architecture in Egypt; while all vestiges of Punic civilisation are lost, both on the African continent and in the Spanish peninsula.

Turning our attention next to Egypt, we find in the remains of Antinoë very curious and interesting examples of Roman art. At Alexandria many fragments are constantly being brought to light, and used in works now in progress; and Pompey's pillar has been made familiar to us, both by pen and pencil. Abd-al-Latif, an Arabian physician of the time of Saladin, says, in his description of Egypt, that he had himself seen on the coast more than four hundred columns broken in two or three pieces, of which the material was the same as this column, and which appear to have been from one-fourth to one-third the size. He adds that he could see by the fragments, that they had originally been covered with a roof. The translator states that this explains the origin of the Arabic name for the column—Amoud Alsawari, or the pillar of the colonnade; proving that it was originally placed in the centre of a forum, in the manner of that of Trajan at Rome. Denon gives a sketch of a column at the ancient Oxyrinchus, which appears of a colossal proportion, and with the remains of the architrave still existing on the capital; but the chapter in which we are led to expect the description gives us no dimensions.

The remains of Petra in Idumæa have been familiarised to us by the labours of Roberts and Laborde; but apart from their value as examples of a peculiar style, it is a subject of much interest to have a satisfactory elucidation of their date and of their history, in obtaining which careful search for inscriptions on the spot might no doubt materially assist. It is to Palestine, however, that we must look for a rich harvest of Roman architecture, in a field as yet almost untrodden by architects. Baalbec and Palmyra, the most important of its cities, have been to a certain extent investigated; but Palestine abounds with other Roman remains, which have been hardly sketched, much less measured and correctly delineated. At Antioch we find triumphal arches. At Missema, the remains of a small but beautiful hexastyle Doric temple, the interior decorated with four Corinthian columns. At Ezra, the ancient Zarava, the ruins occupy a space of three or four miles in circumference; among others a large quadrangular edifice with thirteen rows of arches, five in each row; and in every part of the town Greek inscriptions. At Amyouan, between Beyrout and Tripoli, is a tetrastyle Ionic temple, adorned with rich sculptures. Gerash appears to be one of the cities most fertile in architectural remains in this district, next to Baalbec and Palmyra. Among other objects is a temple near the gate, and facing it a large semicircular colonnade of the Ionic order, most of which, with the entablature, is still standing; the centre of this, exactly opposite the portico of the temple, opens upon the principal street of the city, also flanked by colonnades, and above a mile in length. There is also a large peripteral temple of the Corinthian order, surrounded by a double colonnade of smaller columns, in the manner of the temple of Venus at Rome.

At Damascus there is a fragment which has been already brought before the notice of the Institute. There are many others of which professional descriptions are wanting. The history of Baalbec and Palmyra is involved in much obscurity; and yet, architecturally speaking, these cities, with Petra, are among the most wonderful and interesting in the world. Petra for its extraordinary situation and character; Baalbec for the beauty of its style, and Palmyra for the unequalled extent of its remains.

In Asia Minor, notwithstanding the labours of recent travellers, what remains to be done in the investigation of ancient remains far exceeds what has been already accomplished. Some notice of the remains of Termessus have been already brought before the Institute; but in Caramania there exist some valuable remains of other cities; among others, those of Side. The walls are in some places perfect, and offer a curious example of ancient fortification, besides the usual accompaniments of an ancient city. There are some interesting antiquities at Cacamo. A bath with piers supporting a vaulted roof of considerable space; and a granary built by Adrian or Trajan. It appears to have been customary to erect public granaries along the lines of the main roads for the supply of the troops on their march.

It is needless to dwell on the Roman works at Constantinople—the aqueducts and cisterns have been often sketched but never measured. In Romania and other parts of the North of Turkey in Europe, as well as in Dalmatia and Istria, and wherever the Roman sway extended, monuments of more or less interest are to be found, the number of which might no doubt be increased by further investigation and research.

Remarks.—The Chairman observed, that Mr. Bell had opened a wide and interesting field, and many present had no doubt traversed some of the ground he had been over, and might be able to add some further interest to his remarks. It occurred to him (Mr. Fowler) to mention as an instance, that the road near Caudebec, in Normandy, passes through the remains of a Roman theatre or amphitheatre, having circular arcades. He had not seen any notice of these remains.

Mr. Tite, Fellow—explained that they are situated at Lillebonne, anciently Juliobona, and are intersected by the old road from Havre to Rouen. There is in the same town a remarkably fine church of the Decorated period, of which he could not find a view or plan in any of the illustrated works on France. The members were much indebted to Mr. Bell for the pains and research exhibited in the paper just read. Mr. Tite had no doubt that much might be learnt of ancient art, *out* of Rome; but at the present day, we learn nothing of Roman architecture, either in Rome or out of it. Nothing but mediæval architecture seems now to be the fashion, a circumstance which must be a matter of regret to all who have studied in earlier days a style which he considered infinitely better adapted to modern times and purposes. He would venture to say how necessary and essential he held it to be, that a young architect should study the remains of Greece and Rome. Mediæval art would no doubt afford useful principles of design and construction, but he could not conceive that a good architect could regard his studies as complete, without a distinct investigation of the principles of Greek and Roman art. We are too forgetful of those principles in the present day, and therefore he the more valued the efforts made by the author of the paper just read; particularly as showing how much may be learnt in connection with Roman architecture out of Rome itself. With regard to Roman architecture in Spain, a work written in Spanish, by Pons, may be considered to contain an excellent account of the Roman remains in that country. It was printed in eight or nine small duodecimo volumes, about the and of the last century. Mr. Tite then moved a vote of thanks to Mr. Bell.

Mr. Donaldson, Hon. Sec. For. Corr., observed, in reference to the introductory part of Mr. Bell's paper, that we should not suppose that the Romans were employed solely in conquest, and not in diffusing a knowledge of the arts, because it must be well known that a great civilising spirit existed in them, and that wherever their conquests extended, they endeavoured to introduce good forms of government and municipal institutions. They expended large sums in the erection of monumental edifices in their provinces, even in England itself; and it must be a matter of regret that we have not a work worthy of being cited as 'Anglia Romana,' possessing as we do, a great number of buildings worthy to be recorded. If we had such a work, well illustrated, in the style which our works on mediæval art display, we should bring to light a number of interesting facts. Indeed, it ought to be a national work, promoted by the government. With respect to the monuments at Petra, he thought, from looking at the engravings that have appeared, that they present no evidence of Greek art at all, and that they must have been erected during the Roman dominion, in the time perhaps of the Antonines. With respect to the cities on the coasts of Asia Minor, reference may be made to the letters of Pliny, which recite the great number of buildings erected there under the Roman empire. It had occurred to him that all the buildings erected by the Romans out of Italy, are of a much lower class of art than those in Italy itself, and they are apparently of a later period, and have not the refinement of the Italian specimens.

Mr. Scoles, Hon. Sec., mentioned that it had been ascertained that the column of Pompey at Alexandria, had been originally an obelisk, which the Romans had rounded and converted into a column; this became apparent on making some excavations underneath, when the hieroglyphics were discovered.

Mr. Tite, Fellow, said that Mr. Barry had made during his travels a correct plan and a collection of sketches of the most accurate kind, of the ruins of Gerash and other neighbouring cities, which he had closely investigated.

Mr. G. Godwin, Fellow, called attention to the excavations in progress at the Roman castrum, at Lymne in Kent, where, for want of funds, a Pompeii close at home is entombed, which might be opened for the satisfaction and instruction of all England

Mr. C. H. Smith, Visitor, expressed his doubts as to the accuracy of the details and ornament given in the large works, under the names of Dawkins and Wood, though the measurements might possibly be correct. He had seen the original sketches some years ago, and observed that many of them were very slight, and that the drawings taken from them for the engraver, were made up in the style of ornament then in vogue, rather than in the spirit of the originals.

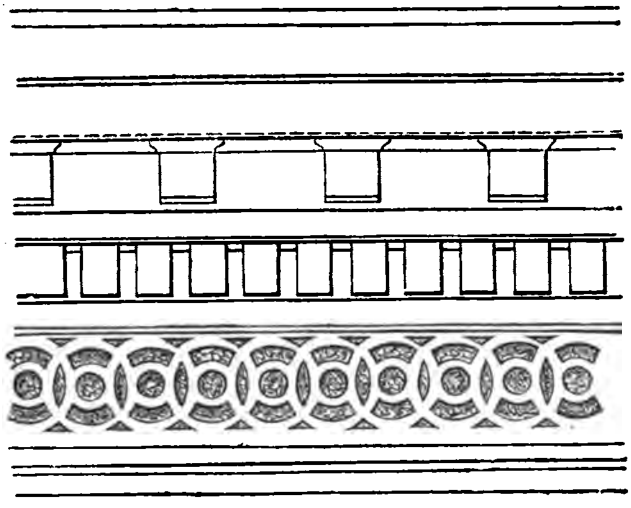
Mr. Scoles, Hon. Sec., observed, when he was at Baalbec he had not that work with him, but his impression of the originals was, that they were equal, if not superior, to the finest specimens he had seen in Rome; the ornaments were elaborately and finely executed, and the Corinthian porticoes in his opinion where the finest in the world.

The Chairman, in announcing the vote of thanks, expressed his regret that Mr. Bell had not divided his ample and interesting subject into two papers, instead of condensing it, in order to bring it within the scope of one evening's proceedings. He then made some remarks in allusion to the Palace of Diocletian at Spalatro, which, judging from the remains as illustrated in the work published by Adam, had evidently been erected after the decline of art in the Roman Empire, and which, though designated as a palace, was in point of fact, intended for a fortress.

NATIONAL PROVINCIAL BANK OF ENGLAND, DARLINGTON.

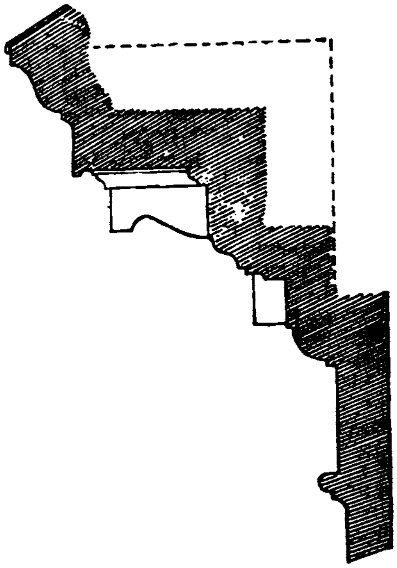
Those who look back to the last century will find, that whatever opportunities it afforded the architect for great monuments, it was far from yielding the same scope in street architecture as now. Churches, chapels, and mansions there were then, as now; but we are much better off with the banks, clubs, assurance offices, colleges and schools, not to speak of county courts, and many more classes of public buildings.

The subject we now give is not one of the more ambitious of its class, but is a very good example of the application of moderate resources. It is the building occupied by the Branch of that large company, the National Provincial Bank of England, in the respectable town of Darlington, and in which there are now two joint-stock banks. It is situated on the High Row, in a very conspicuous part of the town, facing the principal approach from the York, Newcastle, and Berwick Railway Station.



Elevation of the Top Cornice of the Front.

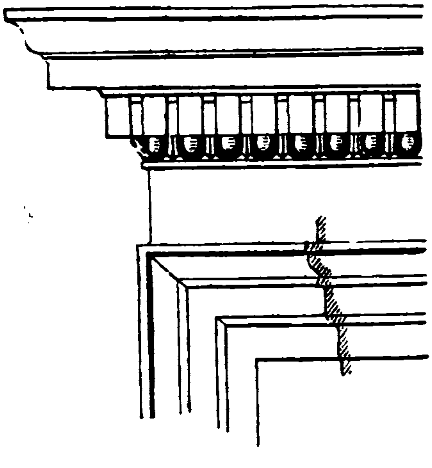
The design for this structure was entrusted to Mr. J. Middleton, an architect practising in Darlington; and we are happy to have the opportunity of giving this proof of his successful application. The site is, it will be seen, narrow, and the means at Mr. Middleton's disposal small; but by careful disposition and study, he has produced a building which, without pretension, is effective, and which it is none the less pleasing is completed within the estimate. We are very fond of columns when properly applied, but we are much better pleased in a composition of this kind to see that their employment is not attempted. It too often happens that stereotyped columns and pilasters are stuck on, by their ostentation to hide the architect's poverty of labour and resource; whereas, when such adventitious aid is rejected, there is always the hope of careful treatment. This, we consider, has been the result in Mr. Middleton's case, as the Elevation will show, and the details of some of which we have given engravings.



Section of the Top Cornice of the Front.

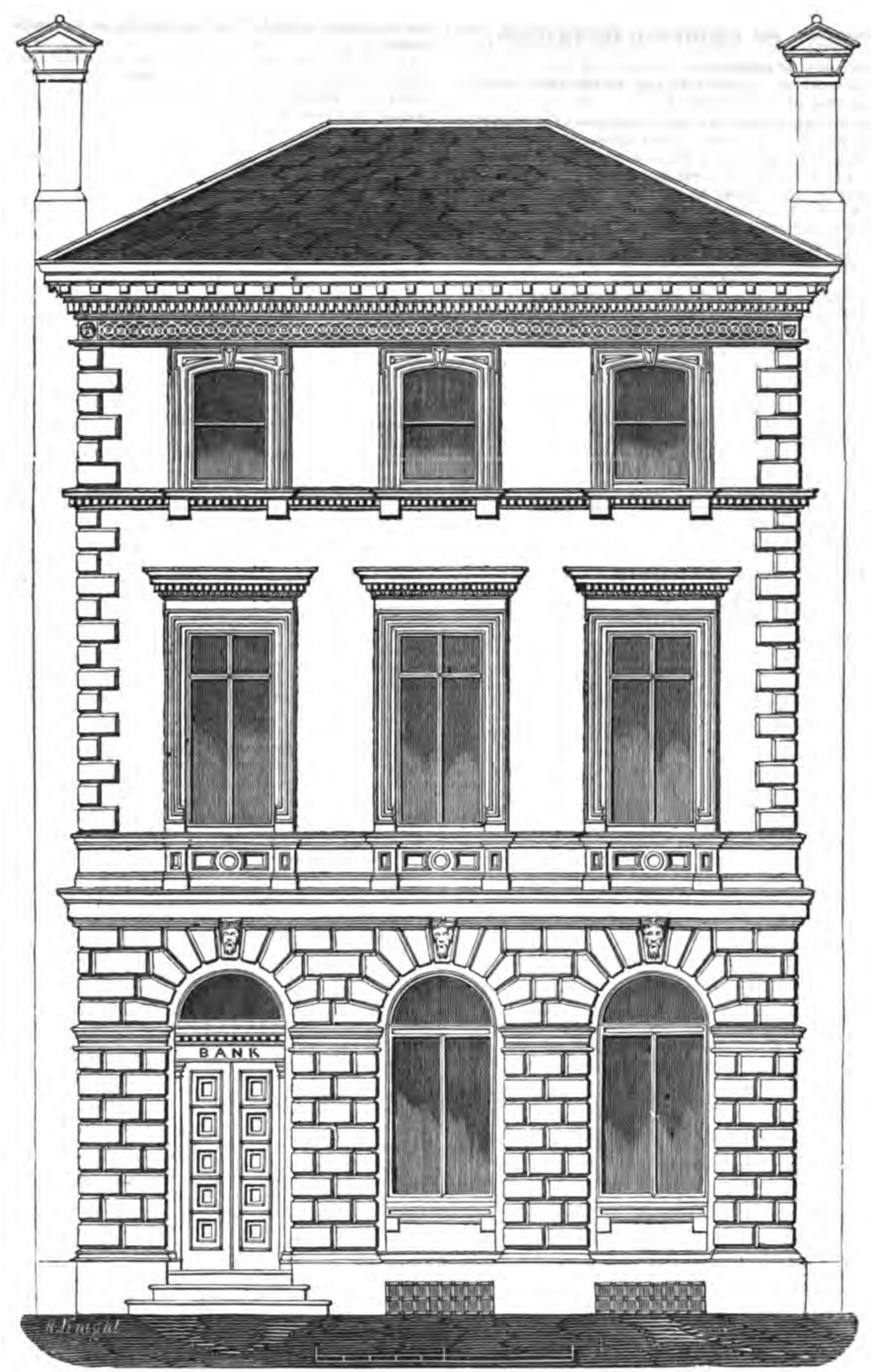
The management of the ground-floor is very good, and by attending to the breakings of the joints, the line of composition is carried up to the first-floor windows.

The treatment of the cornice, without being expensive, is rich; and the boldness of the proportion affords shadow and relief. The finish of the middle range of windows is likewise in good keeping. Whether the masques on the ground-floor keystones might not have been supplanted by emblems more significative, we leave to the architect to settle. Some local or commercial association might have had its meaning expressed.



Section and Elevation of Cornice to the First-floor Windows.

The building is of stone from the neighbourhood, and was erected this year. The internal arrangements afford the usual accommodations of a banking establishment, and for the domestic requirements of the resident and manager, Mr. M'Lachlan.



NATIONAL PROVINCIAL BANK OF ENGLAND, DARLINGTON.—J. MIDDLETON, Esq., Architect.

DEVELOPMENT OF GEOMETRICAL TRACERY.

On the Development of Geometrical Tracery. By the Rev. G. A. POOLE.—(Paper read at a meeting of the Architectural Society of the Archdeaconry of Northampton)

IT is sometimes objected to one who complains of a defect in any system of which he is treating, that he ought to produce a remedy for this defect. This, as a general proposition, would be at once rejected by every one, and yet, perhaps, every one is alike ready to apply it to those whom he does not affect, or of whose treatment of a subject he does not approve. And this, at least, must be admitted, that one who professes that he has seen the evil is not the last from whom the remedy may be expected. And having again and again felt, and professed to have felt, the inconvenience of the arrangement of Rickman, and of every architectural classification, where the style which intervenes between the Early English and the fully-developed Decorated is concerned, I shall now endeavour to justify my complaints, and to prove that there is such a generic difference between that style and the Early English and Decorated, on either hand, that it ought to have a distinct place in an architectural system and a distinct name in architectural nomenclature.

It is at once apparent that the styles of Gothic architecture are arranged very much with reference to the character of the windows. Right or wrong this is the case; and right it certainly is in the sense of being obvious and convenient; though it might perhaps have been expected that some more organic part of the structure might have afforded the characteristics of style. It should be considered, however, that the divisions of Gothic architecture are but sub-sections, or species; not kingdoms or genera. They are not analogous with the divisions of animals into vertebrate and molluscous, for this is parallel with the primary division of architecture into that of the arch and of the entablature. These grand divisions, then, being based on organic differences, it does not seem incongruous that the minor features of a building—even, if necessary, features far inferior in use and in powers of expression, to the window—should afford the differentials of genera and species.

The great point is, that the differences be constant and tangible; but here is the difficulty. There are facilities and difficulties in all systems, and in all parts of systems. It is easy to separate, in general, between a plant and an animal; it is easy to define the difference between the architecture of the arch and of the entablature; but there is a debateable province in both cases; in architecture the whole class of Romanesque buildings; in Zoology the countless species of zoophytes. Again, it may be as easy to distinguish, in general, between Decorated and Perpendicular as between a beast and a bird; but the buildings are countless which have as many of the characters of each style as the ornithorynchus has of the mole and of the duck. I wish this to be distinctly borne in mind all along, lest I should seem to fail in establishing a distinction; whereas, it is the very condition of all such distinctions that they shall have their vanishing point, not to the eye only, as where the sky seems to meet the earth at the horizon, but in the very nature of things.

And now what do we see, if we follow the forms of windows during the last half of the thirteenth and the first half of the fourteenth century? We see them gradually deserting the narrowness and simplicity of the lancet form, till, at last, they have arrived at a great variety and complexity, involving proportionate width of opening and the subordination of many parts. We see, in a word, a wide opening filled with mullions and tracery. And this tracery is composed, at first, of geometrical figures, following certain laws, and afterwards of figures no longer geometrical, and, though not without law, yet of that free flowing contour, which looks at least without restraint. Now, I think you will agree with me, that the first change and the last—the change from Early English to Geometrical, and the change from Geometrical to Flowing Decorated—both demand to be treated as the differentials of a style; the first, that is the mere introduction of tracery, as being, so far as windows are concerned, more important than the difference between Norman and Early English; the latter, the change of the laws which govern the formation of tracery, as being at least as important as any difference which separates Perpendicular from Decorated. In other words, Geometrical is more unlike Early English than Early English is unlike Norman; and so, *ex abundanti*, Geometrical and Early English should be separated; and, again, Geometrical is as unlike Flowing Decorated as Flowing Decorated is unlike Perpendicular; and, therefore, if the two latter should be distinguished, so also should the two former.

And yet, the Geometrical is almost always treated as transitional (which, indeed, every style but the first and last must be, in some sense; but I mean that this is *so* treated as transitional, as if it had no claim to a name and station of its own); it gets no better title than Late Early English, or Early Decorated, as the case may be; the term Geometrical being only adjected to the generic term Decorated, as marking, not a genus, but a variety. If this had no practical result, it would be little worth contending about; but I believe that it really does result in the too great neglect of this style, as a model, and, at the least, a point of departure for modern practice. A style which deserves, but does not obtain, a substantive position, is sure to be defrauded of more substantial proofs of the estimation in which it ought to be held.

It is not my intention to enter at length on the process by which tracery was gradually evolved from the juxtaposition and grouping of several lancets. This has been done often enough. I assume that you are all well acquainted with it, and commence from the time at which *Tracery*, properly so called, was freely used; from the time, that is, when the portions of wall which separated lancets were attenuated and moulded into mullions, and when the piercings of window heads had left no portion of intervening stone-work of greater breadth than the interlacing of two equal tracery bars required.

And now imagine yourselves walking round some great minster at night, when the interior is lighted. I know no better way of coming at the effect of the windows taken apart from the rest of the fabric. Let the nave and south transept be Early English, but let the choir have been built towards the end of the 13th century, and, consequently, with windows filled with Geometrical tracery. As you turn the corner of the transept and get the first glimpse of the Geometrical choir, you feel yourself carried into a new age of design and of construction. But the north transept is Flowing Decorated, or Perpendicular, I care not which. As you leave the choir, and get a sight of this portion, there are differences, indeed, plain enough, even though the windows only are visible, but they are as nothing compared with the difference between the nave and the choir. Or, in other words, the difference between two kinds of tracery is as nothing compared with the difference between tracery and no tracery.

But, say some, the only appreciable differences are those of the windows. First, for argument sake, I grant it; but I have shown why differences in the windows may very well become differentials of style. But, secondly, in truth, I deny it. I deny that there are no differences of characteristic details between the Late Early English and the Geometrical, and between the Geometrical and the Early Decorated. And I deny this the more emphatically, because I shall not now stay to point out the differences: I shall merely ask you to take my word for it, that they run through every part of the structure, in composition, in detail, in decoration, even in construction—the latter, indeed, being demanded by the change in a matter of so great mechanical importance as the relative proportions of the windows, which, you will remember, are arched piercings of the outer walls, of no small relative magnitude.

But, at present, I confine myself wholly to the windows, and even yet more exclusively to the tracery, omitting even to notice cusping, the natural correlative of tracery, except where it follows the same laws as the tracery, which, in the Geometrical style, and in that alone, it often does—so much so indeed that a drawing of the tracery of one window may be converted into that of the cusping of another, only by altering the scale.

The first impression conveyed by a Geometrical window and a Flowing Decorated window side by side, is, that while the former is obviously drawn wholly with the compasses, the latter seems at least to be drawn in some degree *libera manu.* Perhaps this impression, so far as the Flowing Decorated is concerned, is hardly correct; but you will presently see that it results from certain appreciable causes, and indicates a real difference of principle in design. Take the simple Geometrical and an equally simple flowing two-light window. The eye at once detects the use of the compasses in the one, and the very centres from which the curves are struck; in the other no single curve is sufficiently simple to be referred, except with considerable effort, to its centre or centres; it seems, indeed, to be drawn without any mechanical aid. Take more complex arrangement, and still the same character is found carried out through 3, 4, 5, 6, 7, 8, 9 lights. This alone, as it seems to me, is sufficient to demand a separation of the two styles; for in speaking of design, this very fact, that the designer is put into so different an attitude as that of one who is limited wholly to geometrical forms, and of another who allows himself, or seems to allow himself the license almost of a sketch, is surely enough to separate between them.

But the free hand of the later designer had its rules too, and those rules were apposite to those of his predecessors, and this is really the differential which I shall propose. In designing a Geometrical window, the architect adhered to true circles, or parts of true circles, never flowing off into another curve struck from another centre. The ogee was unknown. Cusps,—besides a characteristic so remarkable that I must refer to it, though parenthetically (besides their being *let into the soffit*, instead of being *taken out of the chamfer*—besides this, cusps) were of circles, or parts of circles, struck from circles within the greater circle, independent of one another, but with absolute dependence on the centre of the first circle; these points were cut off by another circle, concentric with the first, or that which circumscribed the whole figure. Hence a transparency of purpose and a precision of effect in this style never afterwards attained. All is complete in itself; and each member perfect, either as a part or as a whole—a character which Professor Whewell abundantly recognises when he calls the Geometrical Complete Gothic.

It must be confessed, however, that something of sameness and of restraint resulted from the use of the compasses, restricted by so narrow laws. This was remedied in a subsequent development of the same style, which let in far greater variety; sometimes amounting almost to license, and yet I think not quite. Indeed, though the forms on which I am about to touch must have often struck us with surprise and pleasure, I think they have never yet been fully appreciated. Mr. Sharpe, in his work on 'Decorated Tracery,' alludes to them thus equivocally: "Towards the close of the Geometrical period there occurred some attempts at originality in the designs of window tracery. Becoming apparently dissatisfied with the extreme formality of the usual geometrical forms, several fanciful experiments were tried by the builders of this period, which, without betraying any symptoms of impending change, present—under forms which may still be termed Geometrical—very little similarity in their general outline to the (former) examples." Now this variety, which Mr. Sharpe seems to consider purely fanciful in effect and abnormal in structure, I shall endeavour to reduce to certain rules, and to elevate, by consequence, to a higher rank.

I admit that it is an escape from a certain very stringent law; but look at the result, and you will be pre-disposed to find in it a recognised rule of its own. In its effect it amounts to a sort of facetiousness of design; a juxtaposition of curiously associated and highly contrasted parts, but yet, without ever losing its precision; so that playfulness and repose are combined in it, just as they are in the most irresistible kinds of wit. Every thing is trenchant, piquant, scintillating, yet still retaining the very strongest expression of precision and *retenue*.

And how is this point gained? By the interlacing of two figures—to speak in general terms—similar, that is, each a square or triangle for instance, but of exactly opposite texture, one being composed of parts of circles struck from within, the other of parts of circles struck from without, the resulting figure (whereas, before, all were struck from within), which distinguishes this from the former variety of the Geometrical style: and yet they still continue always to cut, never to flow into one another, which distinguishes this from the Flowing Decorated. Here is, for instance, a trefoil from Beaumaris thus treated, and a square from Great Bedwyn, to which last example I shall recur presently. And there is, again, the same resemblance between tracery and cusping here, as in the earlier Geometric;—what is tracery at Beaumaris being cusping at Stoke Dry; what is cusping at Canterbury being tracery at Great Bedwyn. Now you will observe how these figures are formed—the pointed figure by curves from centres without, the rounded by curves from centres within the figure. And, as for the result, if I could stand with you before the windows, I should at once ask, and be certain of the answer—are they not riant and fanciful, yet still self-possessed and perfectly balanced?

That the fascinations of this new method should lead to license, cannot excite surprise. It must have done so to a vicious extent had the compasses ever fallen from the hands of the designer; but with this guarantee of precision, Fancy might almost disport herself at will. I have, however, already alluded to an instance in which she did a little overstep the bounds of sobriety. At Great Bedwyn, you have subsidiary tracery breaking in upon the gravity of a principal mullion, like Folly attempting to discourse with Reason in one of Moore's melodies. I do not think Beauty can be offended at the result, but Order may, and it has certainly a revolutionary aspect.

And, in fact, a revolution is not only at hand, but it is clearly indicated, notwithstanding Mr. Sharpe's remark that no symptom is betrayed of the approaching change. We have already drawn circles from centres sometimes within and sometimes without the resulting figure; presently we shall not only do this but also let those circles glide into one another, so as to form complex curves, and we shall have the flowing tracery of the fully-developed Decorated.

But, before we do this, let us attempt to assign names to the two kinds of Geometric tracery with which we have already formed acquaintance.

For the generic term, or that including the whole of that tracery which is formed of circles, or parts of circles, secants and tangents of one another, but never flowing into one another, we cannot hesitate in taking that commonly in use—*i.e.* Geometric. To supply names for its two sub-divisions is not so easy. It is now some six months past that I endeavoured to do this, in an article in the *Archæological Journal*, where I ventured to suggest the terms Concentric and Excentric, to express the opposite characters of the two divisions. The first, you will observe, is of patterns formed of circles, or parts of circles, all the centres of which are within the resulting figure; and, as the figures are all uniform, even the subordinate parts must be repeated with the same necessary relation to the general centre. Thus, in a circle enclosing six other circles, grouped around a seventh (as at Grantham), the centre of the seventh is the same as the centre of the containing circle, and the centres of the six others all lie in the circumference of another circle drawn from the same general centre. All form one system, bound by a sort of centripetal force to one centre. The term CONCENTRIC is, therefore, at least intelligible, as applied to this variety of Geometrical tracery.

The other variety is formed by a combination of curves, some of which are struck from centres without the resulting figures; and, if the window is sufficiently complex, these other centres fall within other patterns in the same window, giving, by a centrifugal influence, to the curves to which they belong, a place in another system with another centre. And the term EXCENTRIC seems sufficiently appropriate to this development of tracery—to this group of architectural comets. We have, therefore, *Geometric* for the whole style, and *Concentric* and *Excentric* for its two varieties.

And now we return to description, and to the successive changes of tracery, which we left on the verge of a revolution.

The use of figures composed of parts of circles, some within and some without the resulting figures, had commenced; and this had also the effect of giving to several figures a reciprocal interest in the parts of each other. And this which was partially effected in the Excentric Geometrical, is fully attained in the Flowing Decorated, where the curves run into one another, and each line becomes a part of the boundary of two figures, of one without, of another within, the influence of its own centre.

There are one or two curious results from this.

In the first place, the great variety and the double importance of the lines of the tracery tend to make these the principal object of attention, and whereas before the lines were used to form the lights, now the lights are made to adapt themselves to the lines—a manifest lowering of principle, since mullions are clearly for windows, and not windows for mullions.

Secondly, there is a great tendency to sacrifice apparent security to grace of form. Some Flowing Decorated windows look as if they could not stand without the influence of the window arch, as if the parts were unequally balanced, and a disproportionate weight was laid upon the feeblest part of the feeble curve. This never happens in a Geometrical window.

Thirdly, the patterns are enabled, by accommodating curvatures, to run into every corner of the space to be filled, and the interstitial spaces, which in Concentric tracery are generally triangles, and in Excentric tracery are multiform, either entirely disappear or are made so large as to have their own part in the composition and their own cusping. This is, I think, the only decided advantage which the Flowing has over the Geometrical style, and this is too dearly purchased.

I do not propose to carry my remarks into the subdivisions of Flowing tracery; and I shall therefore be content with giving you one type of it, the common reticulated tracery, which exemplifies almost all that I have said. Here parts of circles, drawn alternately from within and from without the figures which they form, compose the whole of the design; each curve is a part of two figures, and the spaces left by the tracery appear only at the window arch, where the pattern is as arbitrarily cut off as a piece of damask could be with the scissors of the mercer's apprentice.

One objection will be made to all that I have advanced. There are cases where my definitions and descriptions will not absolutely hold. In the window of Great Bedwyn, for instance, there are several ogees. In the east window of Market Harborough, parts of the design are Geometrical, part Flowing Decorated; and so of many other cases. This is very true. But remember that we agreed, awhile ago, that this must always be so, and indeed, it is the case equally with Decorated and Perpendicular, and with all the styles. In Kirkstall, Fountains, and Buildwas, what would be called Norman, if seen alone, actually occurs over what would be called Early English. In Patrington, Yorkshire, the east window is pure Perpendicular, all the rest is Decorated. In many other churches we have windows which cannot be historically separated, yet which cannot architecturally be classed together. These are difficulties which occur now and then, and must occur. Yet they do not render it less necessary to call this or that building as a whole, Norman or Early English, Decorated or Perpendicular. I only claim for the Geometric style the same indulgence.

Directly or by inference I find others agreeing with me in demanding that the Geometrical shall be acknowledged as another style. Mr. Sharpe, for instance, in his work on 'Decorated Window Tracery' (to which I cannot allude without adding a word of very high commendation,) having defined the difference between the windows in what used to be called Early and Late Decorated, adds, "We have only to carry our inquiries a step further in order to satisfy ourselves that these points of difference are not confined to the windows alone, but extend also to the buildings to which these windows respectively belong; and, having arrived at this point, we shall not be long in coming to the conclusion that there exists a large and important class of buildings, characterised by the Geometrical forms of their window tracery, which has hitherto been treated as belonging partly to the Early English and partly to the Decorated style, but which is, in reality, distinct from both, and pre-eminently entitled, from the number and beauty of its examples, to separate classification."

I had hoped, indeed, that before this Mr. Sharpe would have published, with ample illustrations, his own arrangement and nomenclature. In what I say now I would rather be considered his pioneer than as having any substantive importance of my own. Some time past I stated my views to him on this subject, and found that his were already in a far more produceable shape, and I doubt not that he will soon formally claim the title Geometrical, not only for a certain character of window tracery, but for the style of architecture in which it is found.

Again, I find that Mr. Freeman, in his 'History of Architecture,' where he divides all Gothic architecture into two great classes, Discontinuous and Continuous, actually places his one broad line of demarcation where, at present, all distinction is sometimes denied, between Geometrical and Flowing Decorated.

Finally, Mr. Scott, in his 'Plea for the faithful Restoration of our ancient Churches,' a work which is of great interest to the people of Northampton, since the restoration of St. Peter's church is committed to him, and which has few competitors in general importance, claims not only a place, but the highest place, for the Geometrical style. But what he says is too long to be transcribed at length, and too important to be retrenched. I must, therefore, refer you to his chapter *On the Choice of a Style for present Adoption.*

I am not very favourably situated for reference to books here, therefore, my appeal to the judgment of others closes; but not without a formal assertion of the principal objects of my paper. Let us uphold the right of the Geometrical to a place, and that the highest place, among the distinct styles of Gothic architecture.

I fear that the method of my discourse has not tended to produce the impression that I have been wandering with you along one of the most flowery paths of architecture; and yet this is really the case. But you must remember that I have been playing the part, not of the florist, but of the botanist, who is, in comparison, a very dull sort of fellow. Nowhere is THE BEAUTIFUL, for its own sake, more visibly the object of the architect than in the disengaging of tracery, and nowhere has that object been more happily attained. Here he works, to borrow an expression of Ruskin's, as if he was happy as he worked; and we follow him in his task with an ever-growing interest, and look delighted on each successive form and character which he evokes from his stubborn materials. The first germ, hidden from all eyes but those who watch for spring with the impatience of love—the swelling bud, veiling yet promising countless forms and hues of beauty—the bursting flower, compact yet full, glowing yet half coy in conscious loveliness, and all the sweeter for its coyness and reserve—the leaves expanding with a new vigour, crisped with life yet still crumpled with the kindly compression from which they are escaping—the bright smooth petals of the wide-spread flower, tremulous with exultation, and but too ready to fall in their redundant beauty, when Winter, envious or too rigidly severe, lays his icy hand upon them lest they should become wanton in their exuberance—such, almost, are the forms which we have now reviewed in their order and their destiny. We have seen the first germ of tracery hiding countless beauties. We have seen it expanding, but yet under the most severe restraint, in the first or Concentric tracery. We have seen it put forth more fantastic forms—let me repeat the very words, the crisped and crumpled forms—of the Excentric or Later Geometrical; and, finally, we have seen the widely-expanding, half-flaunting, half-fletri Flowing Decorated, stiffened at last, and not undeservedly, into the harsh and hard, soulless and sapless Perpendicular. Oh! that we might be allowed to anticipate a return to the opening bud, and its expansion into another flower of a higher kind of beauty and a better fate!

VERANDAH, SANS SOUCI, NEAR BERLIN.

THE above engraving represents the Verandah of a Flower Window in the head gardener's lodge at Sans Souci, the royal seat of the King of Prussia, near Berlin.

According to the *Annales des Chemins de Fer*, an arrangement has been made by the directors of the North of France and Strasburg Railway Companies, that they will, at common expense, build a line of communication, which will start from the De la Chapelle Goods Station, transect the national line No. 1, from Paris to Calais, the rural roads des Fillettes and la Croix des Evangiles, and join the Strasburg line about 150 yards above the viaduct of the Rue des Tournelles. The whole length of this railway, from one line to the other, will be 1200 yards. When, however, the important plan of a circular line, which will bind together all the lines starting from Paris, shall have been completed, the junction of the North and Strasburg lines will be effected by a small branch line of about 300 yards, which will branch off from the main line of junction. The line will have but one rail, and will be worked by horses, as the space to be traversed is very short.

VENTILATION AS A BRANCH OF SANITARY REFORM.

On Ventilation as a Branch of Sanitary Reform. By William Walker, C.E., of Manchester.—(Paper read at the third meeting of the Liverpool Architectural and Archæological Society, November 13th, C. Barber, Esq., V.P., in the Chair.)

Much had been said latterly about sanitary affairs, and the public health was becoming a leading topic of the day. We had instituted Boards of Health and a Sanitary Commission; several statesmen and men of influence, actuated by motives of philanthrophy, had taken the question under their especial protection, but, notwithstanding this, comparatively little had been done to remedy the evils complained of. True it was, that during the sway of the fatal epidemic last year, temporary expedients were adopted, and a spur was given to sanitary progress. Since that time more copious supplies of water to some large towns, and some few drainage works for removing rapidly accumulating refuse had been undertaken. In public buildings, too, of late years, great attention had been paid to the ensuring of copious supplies of air. The new Houses of Parliament, at Westminster, and St. George's Hall, in Liverpool, were the latest instances of this; the latter of these buildings was, however, so far from completion, that no trial had yet been made of such measures as were adopted during the construction; and, if we might judge from the public prints, doubts seemed to be entertained of their efficiency, so far at least as might be implied from the devoting of a sum of money and a considerable period of time to the trial of further experiments as to the best mode of ventilating it. The walls being apparently completed, the question arose whether that was not beginning at the wrong end, and whether the experiments ought not to have preceded the construction, in order to obviate those difficulties and expenses which must result should the experiments involve a necessity for constructive alterations?

Branching forth into the historical portion of his subject, Mr. Walker said, that if we carried the ploughshare of research into the early days of architecture and engineering, we should find much to astonish us in the progress made by "the world's grey forefathers" in the arts conducive to health. The Roman aqueducts furnished magnificent testimony to the care bestowed by the ancients on cleanliness as a means of health; and Greece, also, made similar provision for her people. The system of sewerage adopted by the Romans was of the most efficient and extensive character. They did not enter into fierce debate whether a six-inch or a nine-inch pipe would suffice, the minimum system not being in force in those days, but they took care that if they erred, the error should be on the side of excess rather than of deficiency. We were only just beginning to establish public baths for all classes, and it was thought to be a great step in advance—but both the Greeks and Romans, and probably the Egyptians before them, had theirs; and the art of heating their buildings and their baths was not unknown to the luxurious Romans. As to the change of air (the more immediate object of this essay), there did not appear to be any special provision for that purpose adopted by the ancients, except by the windows. Change of air was deemed by Vitruvius to be of the greatest importance, but his directions applied almost exclusively to external provisions and arrangements. The moderns had only recently begun to follow the ancient practice of providing open air walks or public parks for the people in large towns, but so far they were on a very inefficient scale; their great distance from the spots where the day was spent in toil, rendering the fatigue of reaching them a great barrier to their use. This objection was anticipated by the Romans, who provided them at all their bathing establishments, theatres, and other places of great public resort. During the "dark ages," which succeeded the decline and fall of the Roman empire, these and many other arts, if not entirely lost and forgotten, fell, at least, into neglect and desuetude; and from that long period of sanitary darkness we were only now, by slow degrees, emerging.

The two natural fluids chiefly concerned in the sanitary art were water and air. The first of these—water—was provided for our use in the greatest abundance—three-fourths of the surface of our planet being covered with it; but air was provided for us in an infinitely greater abundance even than water, the entire surface of the globe being covered with it to the height of about fifty miles.

After treating of the chemical properties of air, Mr. Walker came at once to the subject of Ventilation, which he took to imply motion of air; and where there was motion there must be a mover. In the great process by which the earth was ventilated, heat was the mover, and its effects met with no interruption from opposing circumstances. The earth was not closely hemmed in by other planets, which might obstruct those movements; nor could the inequalities of its own surface offer any serious impediment to the free progress of those enormous volumes of air, compared with whose vastness the highest mountains and deepest valleys might be regarded as almost a level surface. This was natural ventilation, and as in all the processes of art the imitation of nature was our primary rule, so should we best succeed in ventilation by adopting her measures and following her infallible processes. But we must ever bear in mind thar we were not ventilating a smooth, free, and unobstructed ball like the earth. Our art was to be exercised upon the artificial and complicated works of man, who surrounded himself with walls which other men surrounded with other walls; who protected himself from the inclement winter by transparent inclosures; who in progressive stories heaped one building on another; who, in fact, multiplied artificial contrivances for other purposes, each one of which removed him further from a state of nature; whose arts, forms, and usages brought large numbers into an unnaturally small space, and who must therefore use further artifice to obtain that natural supply of the vital element, which his previous wants and proceedings shut him out from. Ventilation was not simply a summer question. At all seasons of the year we must have air. Not only must it be supplied, but means must be resorted to to obtain it at a proper temperature, and to introduce it into our rooms and around our persons in an unobjectionable manner. These considerations at once set at defiance all those numerous devices of the "passive" or (so-called) "natural class," which consisted in admitting air directly into rooms through openings in the windows or external walls. In the rigours of winter they afforded no means of modifying its coldness, and those who might have, inadvertently, to sit near them would testify to the injurious result. Most of them, indeed, carried with them their own refutation, being provided with means by which they might be entirely closed; and so far as his opportunities of investigation had gone, they were mostly very judiciously kept closed in very severe weather. Window ventilators were also open to another very serious objection, which was that in the evening, when dwelling-rooms were most closely inhabited, the gas lighted, and vitiation in its fullest force, that was the precise time when the closing of the shutters put a total stop to the action of the ventilators. All modes of admitting air in winter which did not proceed on the principle of modifying its temperature at or before the moment of its entering, would, however much diffused the openings might be, produce great inequalities of temperature, and frequently also cold and dangerous draughts of air. Mr. Walker then proceeded to point out how large quantities of fresh air might be introduced with certainty into the various compartments of a building, illustrating his views by some examples which had been carried out. In nearly every case constructive preparations had been necessary: the mode of obtaining air had been considered when the building was originally planned, and by the concert thus established between the architect and the ventilator, successful results had been obtained at a minimum cost.

Mr. Walker deferred till a future occasion the more practical part of his subject, which would refer chiefly to the means, constructive and otherwise, which would ensure a supply of air being obtained in proper quantity, manner, and condition.

Remarks.—Mr. Rawlinson (Inspector to the General Board of Health) said this was a subject that he had paid special attention to for some time, and he might, perhaps, be allowed to make a few remarks upon it. He quite agreed with Mr. Walker, that it was time architects took up the subject, and that ventilation should be considered in the structure of buildings. If it was necessary to put a roof upon four walls, it was quite as imperative to make provision for the due regulation and escape of air. Any attempts at ventilation after the house had been occupied, or even the adoption of so-called "ventilators," in chimney breasts, were mere make-shifts. They did not give that which was required—namely, full, free, copious, and safe ventilation. To be safe, ventilation must be diffused; it must also be perfectly under control. He had no hesitation in saying that a well-built house of modern construction, in the metropolis or Liverpool, was the most dangerous tenement that a man could put his head into. He lived in a London house, which was so well built that the door vibrated like an Æolian harp. When he sat by the fire writing, he had to resort to the expedient of turning a bucket the wrong side up to put his feet upon, in order to escape the ill effects of the draught, the fireplace being low. He had no doubt that many literary men who became absorbed in their subject, and got their heads heated whilst their feet were cold, from the draughts which crept along the floor, had their constitutions materially affected from want of the necessary precautions. He expressed his opinion that the corridor, lobby, and staircase of a house should be well warmed, which would do away with those cutting draughts that crept along the floors and were so injurious in winter. St. George's Hall had been alluded to, and Mr. Walker was, perhaps, not aware that Mr. Elmes paid considerable attention to the subject of ventilation in the construction of that building. Every arrangement was made that he (Mr. Elmes) considered necessary, and the assistance of Dr. Reid was called in. The great vaulted ceiling which was turned over the hall had had especial reference to ventilation. Allusion had been made to the ventilation of cottage tenements. As inspector to the Board of Health it had been his duty to travel through the length and breadth of the land, and he had visited tenements of all descriptions. Doubtless many gentlemen in that room had read the statements drawn up by men in office, and imagined them to be overcharged; but he could assure them that there did not exist a man who could adequately describe the utter wretchedness in which the lower classes of this country lived in the nineteenth century, and in the midst of boasted civilisation and refinement. This was not the case in large towns alone, but it was the same in rural villages where Irish emigrants took up their abode. It was laid down as a law that 800 feet of air was necessary for each individual; and he had seen thirty persons snoring fast asleep where there should have been but two. It was high time that this state of things should be altered. He followed the track of the fearful epidemic last summer, and, if he was shown a tenement or house, he could tell whether fever or the cholera would come there or not: there was no mystery about it. If people were crowded together where there was no means of obtaining fresh air, where refuse had accumulated for a long period, there fever would make its visitations, and in times of epidemic the cholera would take up its devastating abode. It was also singular that damp had a great deal to do with it. It was not enough to make the surface dry, but the subsoil should also be in like condition. Something had been said with regard to ancient and modern drainage; and it was certainly very right that we should admire and imitate, so far as we could with advantage, all that had been done by the ancients; but we should be doing very wrong if we followed the example of the Romans, in their large sewers. Mr. Rawlinson contended that the minimum sized drains were most efficient, and that those which were large only afforded space for deposit. Again adverting to the subject of ventilation, he recommended the application of hollow bricks or tiles, which, he said, now that the duty was off, might be made of any size or form. He had made an experiment to test the capabilities of these bricks to carry pressure, doubts having been expressed as to those on which the great ceiling of St. George's Hall was turned, and he found they were capable of sustaining the required weight.

Mr. **Barber** asked if the ceiling to which Mr. Rawlinson alluded was turned at his suggestion?

Mr. **Rawlinson** said it was. The construction of that ceiling gave a great deal of trouble, but it was always Mr. Elmes' intention that he (Mr. Rawlinson) should turn it for him. He had seen at Castle Howard some tile piping, and he did not see why he could not turn the arch of St. George's Hall with them; he had some made with two-inch bore, four inches square, and twelve inches long, which answered the purpose very well.

An interesting discussion ensued, in which Mr. H. P. **Horner** and Mr. J. **Boult** took part, dwelling on the importance of large buildings, such as St. George's Hall, as they were not only an ornament to the town, but promoted public health by the open space which was left around them, besides which they called forth improvements in construction, and in sanitary arrangements, which would not otherwise be thought of.

MEMOIR OF THE LATE WILLIAM MURDOCK.

On the Inventions and Life of the late Mr. William Murdock. By Mr. **Buckle**, of Soho.—(Paper read at the Institution of Mechanical Engineers at Birmingham.)

The subject, interesting in itself, was rendered peculiarly so by the exhibition of several mechanical antiquities, among which may be specially noticed a diminutive locomotive engine, constructed by Mr. Murdock in 1784, and unquestionably the first that ever was made. A bust of the deceased mechanician, by Chantrey, was appropriately placed in the room, and the Rumford medal, awarded to him by the Royal Society, was inspected with interest by the members. The chairman prefaced the subject by observing, that he had the distinguished honour of exhibiting to the present, as the first public Scientific Institution, the very first locomotive engine ever constructed. To the late William Murdock belonged the honour of producing it. He was at that time at Redruth, in Cornwall, and having conceived the idea of making a locomotive, he carried it into effect, as the interesting piece of mechanical antiquity then exhibited, would best testify. A very curious anecdote was preserved in connection with it. On one occasion, having placed it on a gravel walk conducting to the church at Redruth, he lighted the lamp beneath the boiler, and whilst the locomotive was pursuing its course, to the singular dismay of the clergyman of the parish, it attracted his notice, and he fancied that the evil one himself was making night hideous.

The paper was then read by Mr. Marshall, secretary to the Institution. It commenced by observing, that the subject of his notice was born at Bellow Mill, near Old Cumnock, Ayrshire, in 1754, where his father, an ingenious mechanic, carried on the business of millwright and miller. His mother's maiden name was Bruce, and she used to boast of being lineally descended from Robert Bruce, the Scottish hero. So remarkable a man, whose talents and inventions have contributed to the advantage of society, and whose ingenuity was so well known, should not be allowed to go out of the world without some special notice. Little was known of his habits and pursuits prior to his joining the establishment of Messrs. Boulton and Watt, at Soho, in the year 1777, then in its infancy; but he must, before he left his native country, have had celebrity, as he was employed to build a bridge over the river Nith, in Dumfries-shire—a very handsome structure which still exists. His talents were soon justly appreciated at Soho, particularly by the celebrated James Watt, with whom he continued on terms of the warmest friendship to the time of Mr. Watt's death in 1819. After a short residence of about two and a-half years at Soho, he was appointed by Messrs. Boulton and Watt to superintend the erection and undertake the general charge of their engines in Cornwall, where he erected the first engine with the separate condenser in that district; and he remained there, giving great satisfaction to the mining interests, until 1798, when, as a proof of his usefulness, the adventurers in the mines, hearing of his intention to return to Soho, used all their efforts to retain his services, and offered him 1000*l.* a-year to remain in Cornwall; but his attachment to Soho and his Soho friends would not allow him to comply with their urgent request.

In the year 1785 he married the daughter of Captain Painter, of Redruth, Cornwall, and had four children, of whom only one son survives; his wife died in 1790, at the early age of twenty-four years. In 1798, Mr. Murdock returned to Soho to take up his permanent residence, and superintend the erection of the machinery at the foundry connected with that establishment; but he occasionally superintended the erection of engines at a distance, and among others those of Lambeth, Southwark, Chelsea, New River, East London, Westminster, and Essex water-works. His energies to further the interests of Soho were not employed in vain, for they assisted in no slight degree in procuring for it a name celebrated throughout the civilised world. His time, whilst at that establishment, and for years afterwards, was so completely occupied by his mechanical pursuits, that he had no leisure to devote to any sort of relaxation. The rising sun often found him, after a night passed in excessive labour, still at the anvil or turning-lathe, for with his own hands he would make those articles which he would not trust to hands less skilful. Mr. Watt, in his notes on Dr. Robison's 'Treatise on the Steam-Engine,' bears testimony to some of Mr. Murdock's valuable improvements, and others are recorded in a patent he took out in 1799. These, although described by the writer in detail, may be briefly indicated as boring cylinders by means of an endless screw working into a tooth-wheel; beam cases for cylinders cast in one piece, fitted to the cylinder with a conical joint at top and bottom; the double D slide valve for simplifying the working of the steam-engine and saving the loss of steam; the cylindrical valve for the same purpose as the preceding one; and a rotary engine, consisting of two wheels with both working into each other, and fixed in a case fitting close to the sides of the two wheels and the ends of the teeth, these parts being made steam-tight by packing. Mr. Murdock had one of these engines, of about one-horse power, set to work about 1802, at Soho Foundry, to drive the machines in his private workshops; it continued there for about thirty years, and afterwards in nearly constant work, was found to work well.

First Locomotive Engine.—Now that locomotive steam-engines applied to carriages have become so extensively used, it is proper to record that the first so applied was made by Mr. Murdock, upon the principles described in the fourth article of Mr. Watt's specification of 1769—since adopted in all engines for that purpose; and this was seen in 1784, by persons still living, drawing a model wagon round a room in his house at Redruth, where he then resided. This original engine was frequently exhibited by him to friends at his house at Handsworth up to the time of his death, and is still in working order. (The identical engine was at a subsequent period of the evening set to work, to the extreme interest and evident satisfaction of every one present.)

At the time that he was making experiments with his locomotive engine, he greatly alarmed the clergyman of the parish of Redruth. One night, after returning from his duties at the mine, he wished to put to test the power of his engine, and as railroads were then unknown, he had recourse to the walk leading to the church, situated about a mile from the town. This was rather narrow, but kept rolled like a garden walk, and bounded on each side by very high hedges. The night was dark, and he alone sallied out with his engine, lighted the fire or lamp under the boiler, and off started the locomotive, with the inventor in full chase after it. Shortly afterwards he heard distant and despair-like shouting; it was too dark to perceive objects, but he soon found that what he heard were cries for assistance proceeding from the worthy pastor, who going into the town on business, was met in his lonely road by the fiery monster, whom he subsequently declared he took to be the Evil One in *proprià personà*. Whoever has been on one of our modern railroads on a dark night, and seen an approaching train—now no novelty—may easily imagine what effect the awful sight would have on the nerves of an elderly gentleman of the last century; and, although the demon was of small dimensions, yet it was a total stranger, and quite unlooked for in such a locality.

Gas Lighting.—Mr. Murdock is still better known to the public by his invention of applying the light of gas from coal to economical purposes. In 1792 he employed coal gas for the purpose of lighting his house and offices at Redruth, in Cornwall; and this appears to have been the first idea of applying the light to useful purposes, although the gas had been discovered and obtained both naturally and artificially, more than half-a-century before. He had also a gas lantern in regular use for the purpose of lighting himself home at night across the moors from the mining engines that he was erecting to his house at Redruth; this lantern was formed by filling a bladder with gas, and fixing a jet to the orifice, which was attached to the bottom of a glass lantern, the bladder hanging underneath. After various experiments, whereby he proved the economy and convenience of light so obtained, he made a public exhibition of it by lighting up the front of Mr. Boulton's manufactory, at Soho, on the occasion of the general illumination for the peace of Amiens in 1802. He subsequently lighted up some cotton mills at Manchester, beginning with that of Messrs. Phillips and Lee; and he published a paper, describing the advantages, in the Philosophical Transactions for 1808, for which the Royal Society presented him with their large Rumford Gold Medal.

Water Pipes.—In 1810 Mr. Murdock took out a patent for boring pipes for water, and cutting columns out of solid blocks of stone. A machine, constructed according to his principle, was set to work at Soho, and another at Mr. Rennie's works, in London; but the patent was subsequently sold to a company in London, with the object of supplying water of greater purity, by conducting it through stone instead of iron pipes.

Blast Engine.—In 1802 he applied the compressed air of the blast engine employed to blow the cupolas at the Soho Foundry, for the purpose of driving the lathes in the pattern shop, by using it to work a small engine with a 12-inch cylinder, which was connected with the lathes, the speed being regulated as required by varying the admission of the blast. This engine continued in effective use for about thirty-five years, and was only discontinued on the occasion of an alteration of the shop. He also constructed a pneumatic lift, and applied compressed air to ring the bells in his house. With this latter invention Sir Walter Scott was so much pleased when he once saw it in operation at Mr. Murdock's residence, that he had his own house at Abbotsford fitted up in a similar manner by Mr. Murdock. He was the inventor of the cast-iron cement, since of so universal and important a service in the construction of machinery; and he made several experiments on the projectile power of high-pressure steam. A specimen had been preserved, and was now exhibited to the meeting, of a leaden ball, about an inch in diameter, which he fired from a steam-gun against the wall of the Soho Foundry in 1803, as the date inscribed upon the ball bore testimony. Allusion was made to several curious incidents manifesting his ardour of research and carelessness as to personal appearance. In 1815 he erected an apparatus, of his own invention, for heating the water at the bath at Leamington. The first conservatory heated in this mode was that of his son, at Handsworth, which remains in use to the present day.

In his latter years his faculties, both corporeal and mental, experienced a gradual decay, and he lived in absolute retirement. He died on the 15th of November, 1839, aged 85 years; and his remains were accompanied by several old and attached friends, and by the workmen of Soho and Soho Foundry, to their last abode in Handsworth Church, and are there deposited near those of Mr. Boulton and of Mr. Watt. A bust by Chantrey serves to perpetuate the remembrance of his manly and intelligent features.

After the paper was read a brief discussion ensued, in the course of which Mr. Middleton, who described himself as "an old Sohonian," endeavoured to show that the pneumatic lift so well known in Staffordshire, and by members of the Institution, in consequence of Mr. Gibbons' recent paper, was the suggestion of Mr. Murdock, who was entitled to the merit of the invention. To this view Mr. Slate demurred, and said he thought that the invention described by Mr. Gibbons depended upon a principle mechanically different to that described by Mr. Middleton. The discussion was brought to a close by the chairman, who said he thought they must all have been struck with the very affecting exhibition which they had witnessed of that feeling of attachment which, to the present moment, continued so strong in the minds of all those gentlemen who had been connected with those who might fairly be called the patriarchs of mechanical and engineering science in this country. It had been intimated, as a very striking instance of the use of institutions like the present, that Watt, Boulton, Wedgwood, Murdock, Keir, Dr. Darwin, Dr Withering, and Dr. Priestley, were the members of a "Lunar Society," so called because their meetings took place at the occurrence of the full moon. Hence we had Boulton's medals, Wedgwood's medallions, Watt's important discoveries, Keir's experiments in chemistry, Dr. Priestley's discoveries in philosophy, Murdock's numerous inventions, and Dr. Darwin's poetical prophecy as to the power of steam. This was an interesting fact, as showing the advantages resulting from the interchange of thought between men of scientific pursuits and mechanical genius.

THE GREAT EXHIBITION BUILDING—CONSTRUCTION OF THE ROOF.

SOME remarks having been made by us in the *Architect* of the 16th ult., in reference to the ultimate stability of the Exhibition building, they have, we are glad to learn, been most carefully weighed by the authorities, and are likely to meet with attention. Indeed, it is only by careful consideration in the beginning that eventual evils can be successfully precluded, and satisfactory grounds be laid for public confidence in a new and untried undertaking, in the prosecution of which to its completion the national reputation is now at stake. We must neither leave off in our progress, nor must we carry it on to subject ourselves to discomfiture.

In the following semi-official communication in the *Times*, we do not wholly concur; but it contains many points of interest, and shows that the authorities are disposed to make alterations where they may appear requisite:—

"There not only was greater care requisite in order to give rigidity to the central and most trying point of an edifice where safety and strength are so imperatively necessary, but the task of construction presented greater novelty of detail and less sameness of combination, as will be easily understood from the plan. In the first place, with reference to strength and stiffness, the whole structure was, in the opinion of experienced architects—men well qualified to pronounce an opinion—deficient in what is technically termed 'diagonal bracing'—a principle of construction introduced by Sir Robert Seppings into the building of our larger ships, and the importance of which to an edifice like 'The Crystal Palace' will be readily conceived. This mechanical appliance had not been included in the plan, because it was believed to be unnecessary, and likely to prove cumbersome. Messrs. Fox and Henderson, the contractors, still express a confident opinion to that effect, and adduce proofs drawn from slight accidents that have occurred in the course of the works in support of their views. Their most experienced hands also declare that at the top of the third tier there is at present less vibration than at the top of most houses in the metropolis. Notwithstanding all this, however, the building committee have determined that, in the centre at the points of junction of the transept and principal aisles, and also at the extremities and other parts of the building, where any strain is likely to be unduly felt, 'diagonal bracing' shall be introduced. We are strongly inclined to think that in this they have exercised a wise precaution. It is no doubt true that the lightness of construction contemplated by the design of Mr. Paxton may be apt to excite apprehensions of insecurity which are unfounded; but where the slightest doubts are entertained by persons well competent to form an opinion, it is obviously best to err on the safe side."

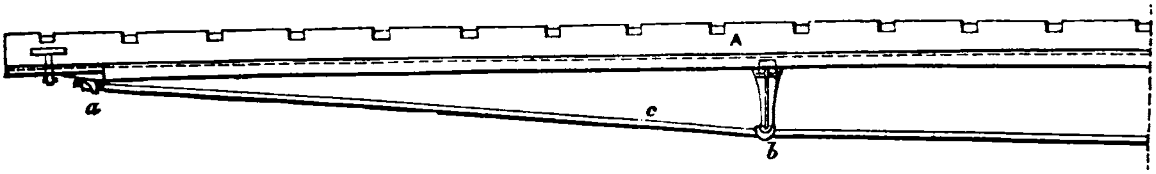


Fig. 1.

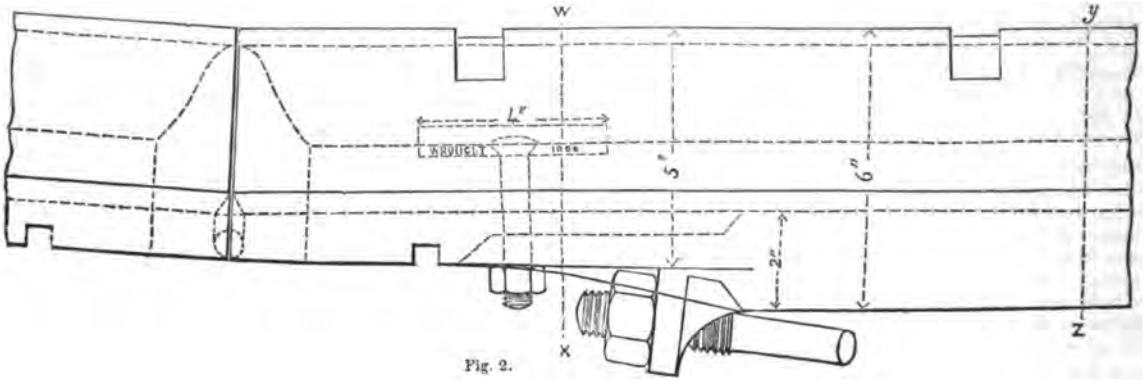


Fig. 2.

Fig. 5.

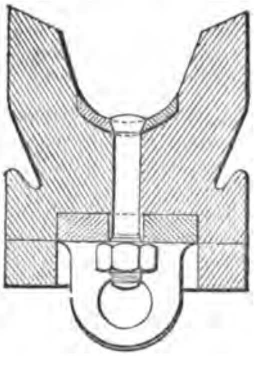


FIG. 3

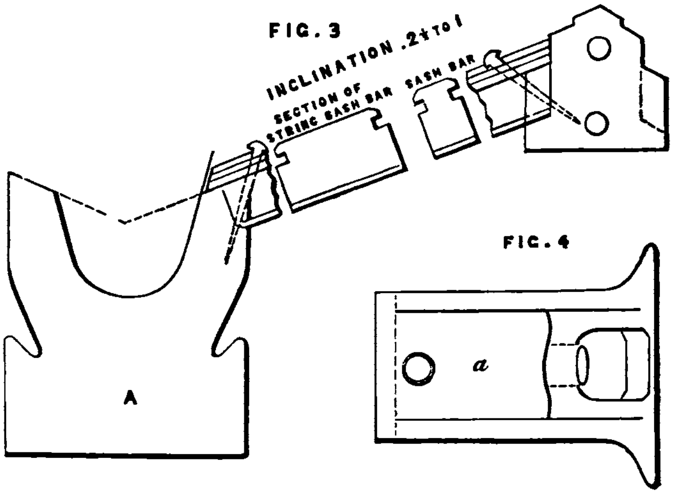


FIG. 4

We have never faltered in our opinion of the ingenuity displayed by Mr. Paxton and his colleagues in the design and in the execution, and we are strongly of opinion that the Exhibition Building will exercise a material influence in extending the range of architectural exertion, and in improving the practice of construction. There is scarcely a part of the building in which some new mode of construction has not been adopted—some new application of mechanical skill, or some economical arrangement been brought to bear. Some things have yet to be tested by experience; but some are patent and decided results, from which example may be already taken. Thus the building has peculiar interest to practical men, and we are glad of every opportunity of giving information with regard to it.

The portion we are now able to illustrate is the structure of the roof; and we shall, as far as possible, conform to Mr. Paxton's own description given at the Society of Arts last week. This subject is of the more interest as Mr. Paxton has for many years made it his particular study, and he has peculiar opportunities of investigating the construction of light roofs.

In 1828, the various forcing-houses at Chatsworth were formed of coarse thick glass and heavy woodwork, which rendered the roofs dark and gloomy. His first object was to remove this evil, by lightening the rafters and sashbars, which was done by beveling off their sides. He also contrived a light sashbar having a groove for the reception of the glass; this groove prevented the displacement of the putty by the sun, frost, and rain. In horticultural structures, such as Mr. Paxton was engaged in, it is of particular importance the light and heat of the sun should not be obstructed; it was therefore his object to get, as far as possible, a glass roof, and thereby a light roof.

Most of the rays of light and heat were obstructed by the

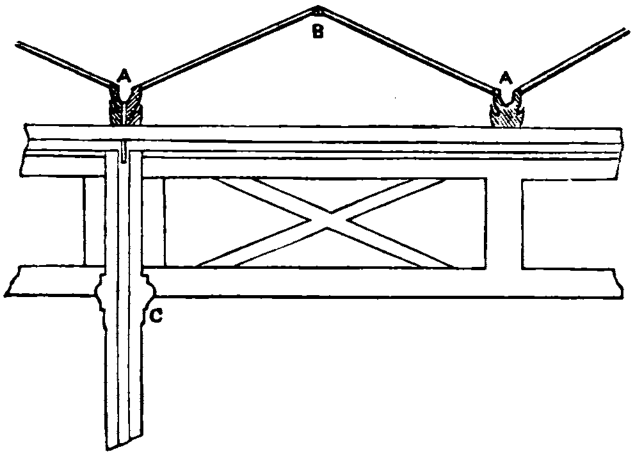


Fig. 6.—Transverse View of Ridge-and-Furrow Skylight.

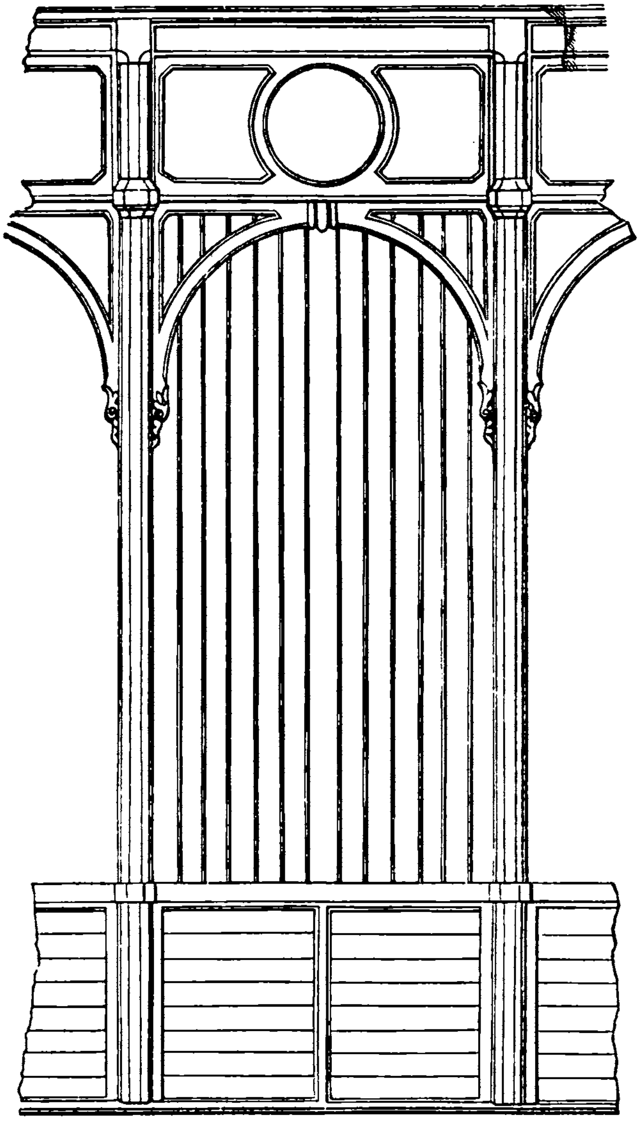


Fig. 7.—Lower portion of Exterior.

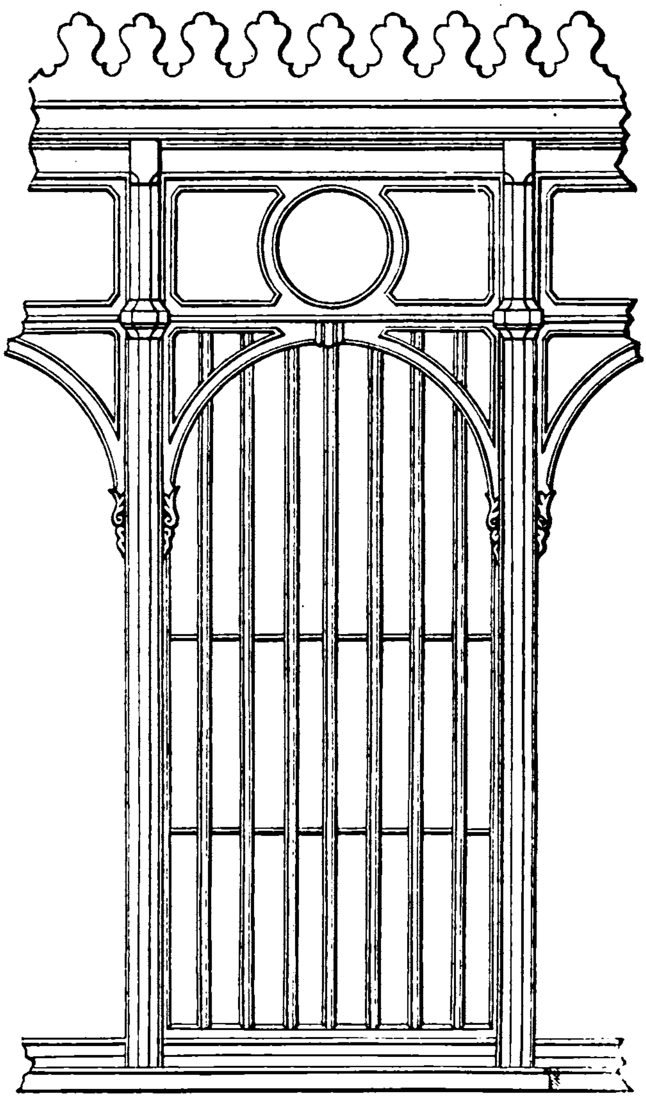


Fig. 8.—Upper portion of Exterior.

position of the glass and heavy rafters. This led him to the adoption of the ridge-and-furrow principle, which places the glass in such a position that the rays of light in the mornings and evenings enter the house without obstruction.

In 1834, he made a further experiment on the ridge-and-furrow principle, in the construction of a greenhouse of considerable dimensions, adopting a still lighter sashbar than any previously used; on which account the house (although possessing all the advantages of wood) was as light as if constructed of metal.

In 1837, in constructing the great conservatory at Chatsworth, it was found desirable to contrive some means for abridging the manual labour required in making the immense number of sashbars requisite. The only apparatus met with was a grooving machine, which was subsequently so improved as to make the sashbar complete. For this apparatus the Society of Arts awarded Mr. Paxton a medal; and this machine is said to be the type from which all the sashbar machines now used are taken. The machine saved in expense 1400*l.* The length of each of the bars made by it is 48 inches, only one inch shorter than those of the Exhibition Building, therefore there was adequate experience as to the working of the sashbar machinery for the Exhibition Building.

The roof of the Exhibition Building is built on the ridge-and-furrow principle, and glazed with English sheet glass, the rafters being continued in uninterrupted lines the whole length of the building. The transept portion, although covered by a semicircular roof, is likewise on the angular principle. All the roof and upright sashes being made by machinery, are put together and glazed with great rapidity, for, being fitted and finished before they are brought to the place, little more is required than to fix the finished materials in the positions intended for them. The length of sash-bar is stated by Mr. Paxton at 205 miles. The quantity of glass is about 900,000 feet, weighing 400 tons.

On each of the longitudinal wrought-iron framed girders is laid a gutter, and upon and communicating with this, four transverse gutters and plates, on which are laid the sashbars of the four ridge-and-furrow roofs and glazing. The water falling on the glass is carried to the transverse gutters in the furrows, thence to the longitudinal gutters on the girders, and so down the hollow columns of the building to the bases, whence it is carried off by 6-inch cast-iron water pipes.

The glass made use of is English crown, 50 inches long, 10 inches wide, and $\frac{1}{16}$-inch thick, running from the ridge-piece to the gutter-plate. The object of this length is to do away with overlaps.

The transverse trussed gutter-plates or troughs are cut out of solid fir-scantling by machinery before they are brought on to the building. These transverse gutter-plates are trussed with wrought-iron rods, bent in the form shown, which can be screwed up or slackened by nuts at the end.

Having explained the general construction, we shall now refer to our engravings. Fig. 1 is half-length of the transverse gutter-plate A, the whole length being 24 feet, width 5 inches, and depth 6 inches. On the lower part of the gutter-plate is seen the tension rod, *c*, 1 inch in diameter, secured by a nut and screw-plate at *a*, and passing through the eye of the queen bolts, *b*. It is particularly worthy of observation that the gutter-plates are made with a camber, so that the rainwater shall fall from the middle of the gutter to the ends, be readily carried off, and be precluded from lodging. The but-ends of the gutter-plates, as shown in fig. 2, are likewise brought together, and fixed in a cast-iron shoe, with an aperture to carry the water down into a square trough.

Figs. 2, 3, 4, and 5, are enlarged views of the gutter-plate, drawn to a scale of one-fourth the full size. Fig. 2 is a side view, showing the ends of the tension rods with the nut and screw, and cast-iron plate fixed to the underside of the gutter-plate, of which fig. 4 is a view of the underside, and fig. 5 a transverse section of the gutter, showing the end of the tension rod, and how the plate is fastened to the timber.

Fig. 3 is another transverse section of the gutter at *y*, *z*, and also of the skylight, showing the wooden bar of the skylight and the ridge. The ridge is worked by machinery out of solid deal 3 inches square, and the butting-joints have ½-inch dowel 3 inches long. The ordinary skylight-bars are 1½ inch deep by 1 inch wide, shown in the small section, with a ¼-inch groove on each side to receive the glass. The other small section shows the form of other intermediate-skylight bars called string-bars, which are 2½ inches wide by 1½ inch deep. It will be perceived by the section, that the skylight-bars frame into the ridge, and are notched on to the trough gutter, being secured at top and bottom by 3-inch nails. For the purpose of taking off any condensation forming within the building which may run down the glass, a groove is provided worked on each side of the gutters.

The skylights are 8 feet span, and have an incline of 2½ to 1.

Fig. 6 is a transverse view of one of the ridge-and-furrow skylights.

Figs. 7 and 8, elevations of the exterior, showing the two stories, the lower being closed with boarding, and the upper glazed. The base, to the height of 4 feet, is fitted with luffer boarding, with the view to ventilation.

If the several details be carefully examined, it will be discovered there are several contrivances to save labour and facilitate fixing. It will be interesting to observe, that in matters so common and so commonplace, there was yet room for the exercise of research and ingenuity.

THE BRIDGE FAILURE AT THE SOUTH-EASTERN STATION, LONDON BRIDGE.

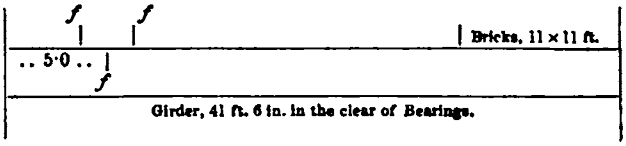
Experience is only true and valuable so far as it is on an extended basis, for though called so, that is not experience which is merely local and partial. We are not always called upon to reproduce the same model or work on the same lines; but our practice is chiefly in the extension or particular application of existing examples. It therefore becomes of the greatest importance that we should have as wide a collection of facts as possible, so as to enable us more safely to calculate the result of any new direction, new application, or further extension; so, indeed, as to secure us from experimenting too far. We want, therefore, not only examples of success, but of failure; we want especially to know where any principle has been strained too much, that we may avoid such extreme, and where any detail has proved defective, so that we may apply the proper remedy. It has therefore always been considered, by our best authorities, as most expedient to record failures. Thus Smeaton prefaces the history of the Eddystone Lighthouse; thus, in the history of the Menai Bridge, the checks received in experimenting, by which the ultimate application was arrived at, are carefully set forth for the guidance of future practitioners. We have therefore felt it highly desirable to report, as accurately as it is possible, a few particulars as to the failure of the Bridge over Joiner-street, at the carriage entrance to the South-Eastern Railway Offices of the London Bridge Station, which took place on the 19th October last.

The bridge is of a peculiar construction, and consists of six compound girders of cast and wrought iron, patented by Captain Warren. The annexed engraving, fig. 1, shows part of one of the girders, rather more than half the length; and fig. 2, a transverse section of the roadway and two of the girders. There are in all six girders, placed 11 ft. 6 in. apart. The girder that broke is 41 ft. 6 in. long, and consists of a series of triplet cast-iron triangles, with a connecting-rib along the top and bolted at the joints, but there is no connecting-rib along the bottom of the girder; instead of which, they are held together by a horizontal tie, consisting in width of four wrought-iron bars, 6 inches deep by 1½ inch thick and 13 feet in length, coupled together by 4½ inch bolts passing through a boss cast on the triangular stays, and also bolted to the intermediate triangles.

The cast-iron triangles are 4 feet deep, with a rib cast on the top 6 inches deep, making the whole height of the girder 4 ft. 6 in., and the length of the triplets 13 feet; the section of the cast-iron is T-shaped, 5½ inches wide on the back, and the depth the same; the thickness of metal 2 inches.

On the top of the girders are laid cast-iron plates, 11 ft. 6 in. long, with ribs bearing at each end on the girders; on these plates rest the materials which form the road, as shown in fig. 2. It must be observed, that the horizontal tie-bars are not intended to act as suspension bars; they are merely connected at the abutment piers to the ends of the cast-iron triangles. The points at which the bridge failed is marked with the letter *f*, where one of the cast-iron stays broke asunder, and also the top rib, as shown in fig. 3, which is an enlarged view of the triangle which failed. It was only 5 feet from the abutment. The fracture is shown at *f*, *f*, *f*.

Various statements have been made as to the cause of the failure. It was stated that the accident was caused by the girder being loaded with a large stack of bricks; but this is doubted, as the stack was at the opposite end, as shown in the annexed diagram.



Girder, 41 ft. 6 in. in the clear of Bearings.

The stack of bricks bearing on the girder was 11 feet square and 5 ft. 6 in. high, equal to 666 cubic feet, which will give, at 72 feet to the thousand, between nine and ten thousand bricks, or a weight of about 22 tons. Another statement is, that the failure was caused by two carts which were on the bridge at the time; one of them, loaded with bricks, it is supposed passed over some obstacle, and caused the wheel to descend suddenly with great force. Whether this be so or not, we cannot pretend to say; but if the bridge had been properly constructed, with a cast-iron girder 41 ft. 6 in. long, and of the great depth of 4 ft. 6 in., it ought not to have broken down with any such force. For ourselves, we are decidedly averse to these compound girders of wrought and cast iron. The contraction and expansion are unequal; and, consequently, the strain must be constantly varying, while the slightest deflection of the wrought-iron must cause the cast-iron to snap asunder.

If this bridge had been constructed with a series of triangles, cast with a connecting-rib at the bottom and a broad flange on the underside equal in weight to the wrought-iron, it would, in our opinion, have stood, and borne a weight far greater than this compound-girder bridge.

The broken rib having been made good, the bridge has been tested with a considerable weight, but with what success we have not been able to ascertain.

Figs. 1 and 2 are drawn to a scale of ⅜-inch to a foot, and fig. 3 to a scale of ¾-inch to a foot.

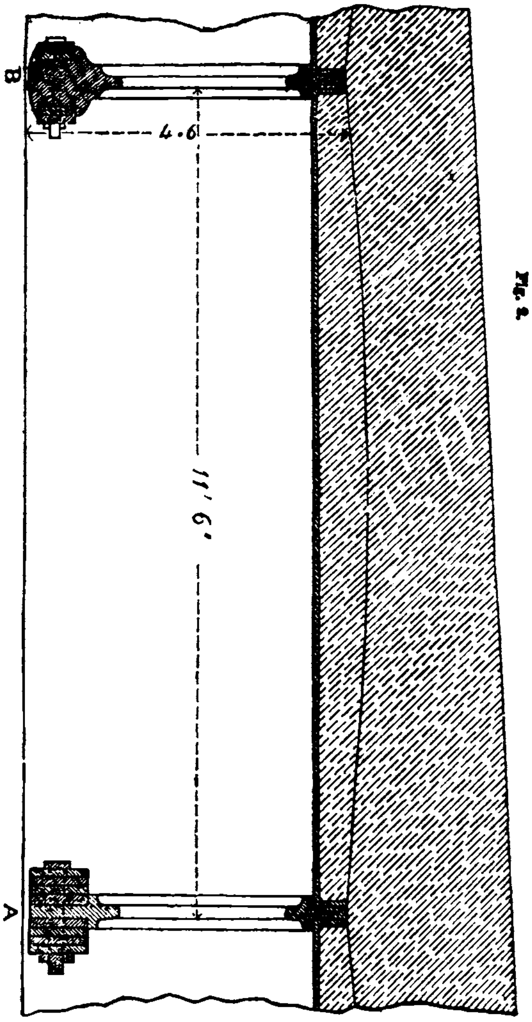


Fig. 2.

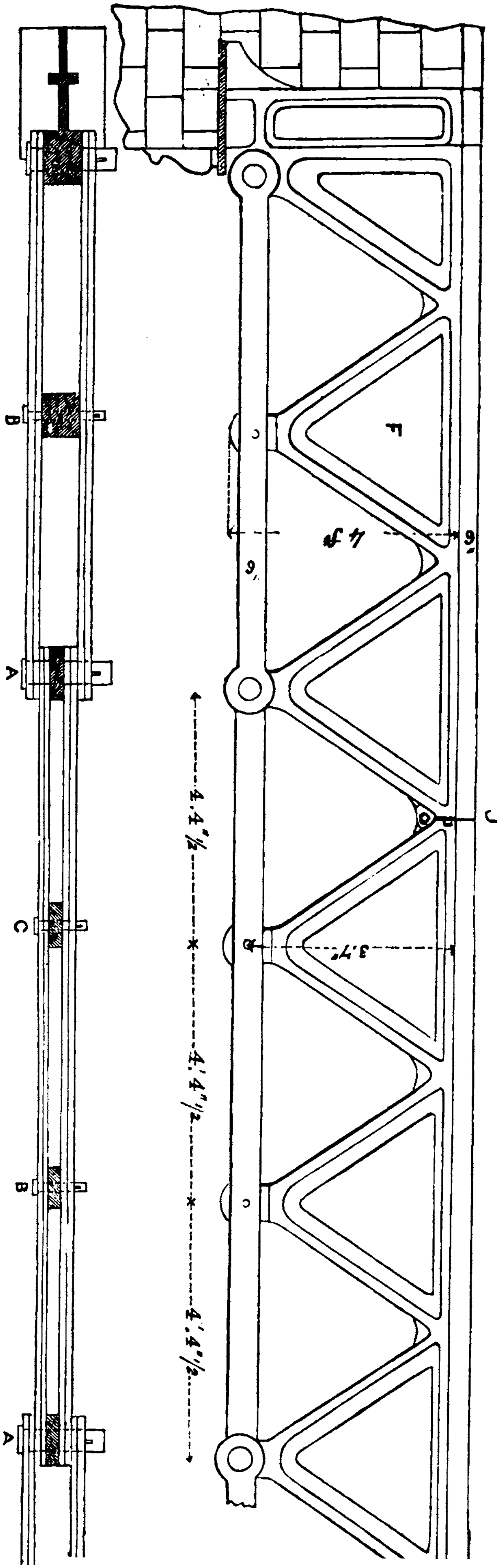


Fig. 1

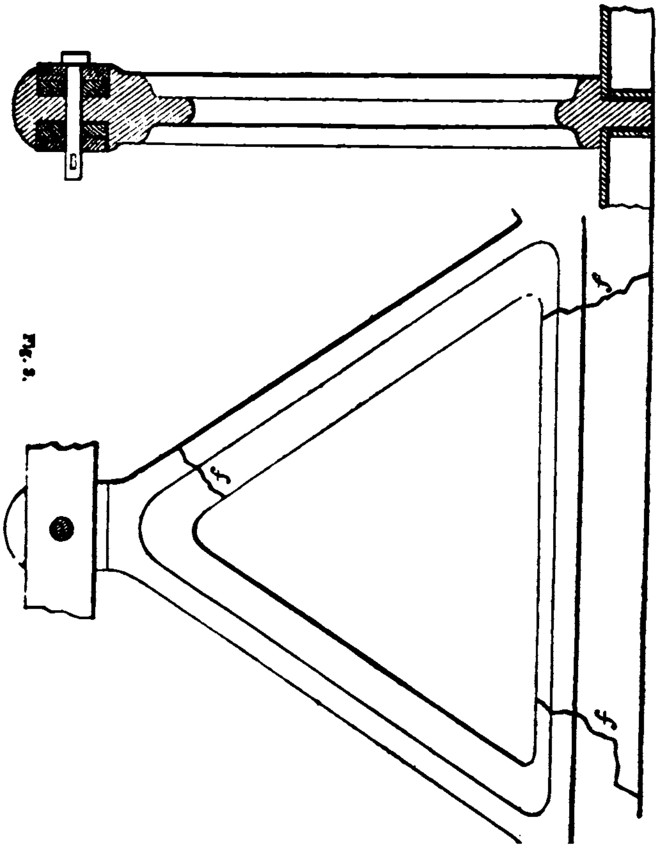


Fig. 3.

SHANNON IRON BRIDGE—GIGANTIC PILE DRIVING.

A most important fact is recorded in connection with the progress of the Midland Great Western Railway Bridge over the Shannon, in the sinking of cylinders of 10 feet in diameter for the foundations. This has been done with Potts's pneumatic process by Messrs. Fox and Henderson, the contractors, who have likewise, we believe, the working of the patent. We mentioned some time ago that these cylinders were in progress of construction, and looked forward with some interest to their application in practice.

In reviewing Mr. Edwin Clark's work on the Britannia Bridge, we had the opportunity of describing the large cylinders which are being put down by Mr. I. K. Brunel, on the Wye, for that remarkable structure which he is now carrying out. The sinking of those cylinders as there described is not in the nature of pile-driving, and although they are of a very large size, yet the 10 feet cast-iron cylinders of Messrs. Fox and Henderson are the largest ever applied in the nature of pile foundations, and on this account their success is of material interest to our readers.

The bridge is, we understand, of iron, and of large dimensions, and is supported entirely on cast-iron cylinders, of the diameter mentioned. The cylinders near the shore have been put down by excavating and the application of weight; but those in the bed of the river, by Potts's process. We need scarcely inform our readers that, in this simple process, an air-pump is employed, which being connected with the head of the hollow pile, the air is exhausted, and a stream of water, sand, shingle, and gravel, rushing up from below, the pile sinks gradually into the displacement made to any required depth. It is therefore a kind of sub-aquatic excavation, the lower end of the hollow pile being converted into a kind of scoop, worked by the air-pump on the platform above. The exhaustion employed was 26 inches of mercury, equivalent to 13 lb. to the square inch; and the cylinder was driven down between 5 and 6 feet in a few minutes, or rather suddenly, until checked by a piece of submerged or drifted wood. The operations were under the direction of Mr. J. Millner, C.E., the contractor's engineer; and the bridge abutments, which are of stone, under Mr. Dargan, the eminent Irish contractor. The cylinders will be filled-in with concrete.

Hitherto the piles employed for Potts's process for sea-beacons, for the Maeldraeth Viaduct, the Black Potts Bridge, and other structures, have been of very small diameter, so that the proceedings we have just described are of the greatest importance. A cylinder of 10 feet diameter gives a large bearing, and four such cylinders will carry a large tablier or platform for a pier, and which can be put down without cofferdams or other preparatory works, thereby greatly reducing the expense of submarine foundations. Here neither cofferdams, caissons, steam-engine pump, nor diving-bells are wanted, only an air-pump of adequate power, which can be easily carried about and rigged anywhere. It will be obvious that unless sunk from the inside (when there would be as much trouble for pumping as by the pneumatic process, and very much labour and expenditure of time), any external application of power would, if it could be employed, exercise a very unfavourable effect on the material of the cylinder. Indeed, a force of much less than 13lb. to the square inch would smash a hollow iron cylinder to pieces. Then again it is to be observed, that 10 feet is by no means the limit of the diameter to which the cylinders can be carried, so that it is open to engineers to design works in situations and under economical conditions where hitherto the resources of art were insufficient to meet the emergency.

IMPROVEMENTS AT GRANTON

Most extensive improvements have been carrying on, for a considerable time past, at Granton harbour, says the *Scotsman*, and a gratifying circumstance in relation to them lately took place. This was the launch of an iron dredging-machine for the deepening of the harbour, from the works of Messrs. S. and H. Morton, who have only recently commenced business at Granton, although well-known in connection with their extensive engineering establishment in Leith Walk.

The name given to the "dredger" is appropriate—namely, "The Howker."[*] It was designed by Mr. Walker of London, the chief engineer of the harbour, who was present and took an active share in the whole proceedings. It is about 90 feet long, and 22 feet wide, with a depth of hold of about 9 feet. The engine with which it is to be fitted up will be about 20-horse power; and it is calculated, we understand, that the dredger will work to the depth of 20 feet from the surface of the water. It is expected to be completed, and in full operation, in the course of a few weeks; and the first work to which it will be set will be to make the inner berth along the pier equal in depth to the outer one, which is from 10 to 12 feet at low water of an ordinary spring tide. Already three barges have arrived at Granton, to work in conjunction with the howker. These are built of wood, and upon the "hopper" principle, by which they are enabled to discharge their cargoes almost instantaneously in deep water. Two other barges, made of iron, are to be built by the Messrs. Morton, and when these are finished, Granton may with truth be said to have a most thoroughly equipped dredging establishment.

Various improvements are going on at Granton of considerable magnitude and importance; in addition to the noble pier that has been completed some time, it is the intention of the noble proprietor, the Duke of Buccleuch, to erect a breakwater on the east side of the pier and another on the west, so as to inclose a spacious harbour on each side. The area is about 77 imperial acres in extent, and that of the eastern about 52. The breakwaters, like two arms, will surround these harbours, with the exception of a space of about 70 yards a little to the north of the point of the pier, which is to serve as an entrance for the shipping. The breakwater on the western side, which is to be upwards of 1000 yards in length, has been in progress of construction for a considerable time, and is all finished except about a hundred yards. The eastern breakwater has not yet been commenced, but arrangements are under consideration for its being speedily undertaken. The height of the western breakwater is about seven feet above high water, so that, even as it at present stands, it will form a pretty good protection for vessels in westerly and north-westerly winds; but when it is surmounted, as it is designed to be, by a parapet wall, the protection will be effectual from winds blowing from either of these directions. In fact, when the eastern breakwater is finished, as it is to be, in the same manner as the western one, Granton will almost be one of the safest places in the Frith of Forth during a storm. These improvements will add very much to the value of that rising port.

It is his grace's purpose to lay down, without delay, a patent slip, of great magnitude, for the benefit of all the large shipping coming to this part of the country. This slip, which will be on the principle of Morton's patent, will be the largest in the kingdom, with the exception of one at Belfast. It will be sufficient to allow vessels of 1000 or 1200 tons to be taken upon it for the purpose of being repaired.

THE WATER SUPPLY OF LONDON.

Report on the Water Supply of London. By the Hon. William Napier.—(Presented to the General Board of Health, Gwyder House, Whitehall.)

Part No. I.

Farnham, Surrey, Oct. 2, 1850.

My Lords and Gentlemen,—Having had the pleasure of receiving in August last your instructions to visit the gathering grounds of the proposed water supply to the metropolis, in order to gauge the streams and make a careful re-examination of the general capabilities of the country for the purpose intended, I have now the bonour to submit to your notice the results of my observations, with a few remarks on the different bearings of the scheme.

On reading the Board's report presented to the Houses of Parliament during the past session, I perceived that from the very short time at the disposal of the Board the calculation of the quantity of water available from the rain-fall on the district, an extent of nearly 150 square miles, was necessarily founded on the discharge of the streams at their outfall.

The Board were thus also manifestly placed under great disadvantage when endeavouring to ascertain the character of these waters; for, as such waters inevitably partake of the nature of the soils through which they have passed, and as the pure sands of the district are not only bounded by clay on the north-east, east, and south-east, by chalk on the west, but are also intersected from east to west in the south by a high range of chalk hills, the course and outfall of these streams present certainly a widely misleading test of the quality of the water to be derived from pure sands.

Considering the purity and softness of the supply to have the first claim upon my attention, I remembered the principle enunciated by the Board, "the nearer the source the better the quality," and made it my first object to examine the nature of the soils in which the rain-fall of the country makes its appearance after percolating through the upper crust, and next, the soils through which it passes to its outfall.

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[*] *Howker* is a Scotch phrase for "digger."

The water-supply of Farnham being derived from the hill on the south side of which the village stands, I bent my first steps thither, not only to examine its source, as likely to present indications for purity to be looked for elsewhere, but also to have a good bird's-eye view of the whole area under investigation. The position of the hill in the south-west, its elevation of nearly 700 feet above the level of the sea, and 300 feet above the plains beneath, admirably adapted it to this purpose. It was then only I discovered that the Farnham water does not come from the surface drainage, but is derived from sixteen small springs, issuing at the south side, on a contour, so to say, about 50 feet above the highest level of the hill. From the contracted area out of which so large a supply is gained, I was induced to suspect that these springs are not due to the rain-fall on the ground above them. I was further led to this consideration by observing that, from the slope of the ground, and from the almost impenetrable hardness of the superficial covering of gravel, the rain-fall could scarcely find its way through this surface. A violent storm having most opportunely come on whilst speculating over this probability, I perceived that the whole of the water apparently ran rapidly down the hill-sides and was speedily out of sight, leaving the surface perfectly dry, except where irregularities retained a few pools, which subsequent observation proved to me were exhausted by evaporation rather than by percolation. I then examined the north side, and found that on the same contour a still greater indication of springs existed. This satisfied me that these waters are due chiefly to rain-fall elsewhere; for a rough calculation of the yield of the springs much exceeded the available rain-fall on the area within the contour.

Convinced of this, I naturally concluded that, if the other ranges of the district were of like geological formation, they would in all probability present similar appearances about the same level; a most desirable source for the streams of the country, the advantage of which, in addition to the proposed drainage supply, could hardly be over-estimated. The first week of my researches was confined, therefore, to the nature of the soil throughout the district, presenting generally a vast depth of pure sands, obscured in the higher levels by extensive patches of gravel from 2 to 20 feet in depth; in the lower, by a poor loam, from one to three feet deep. Patches of peat, here and there in spots of some depth, exist principally in the lower levels. On the west and south-west the loam has a subsoil of very stiff clay, apparently of the London formation, which also crops out on the north side of Farnham-hill. On the north and north-west, in the valleys, there exists within a small area a considerable quantity of iron in some of the peaty bogs. All these are marked upon the plan which I shall hereafter have the honour to lay before the Board, and which I have prepared as accurately as the shortness of time allowed.

The next object of my research was the quality and quantity of the water. The Board, in their report, have given the quantity now brought into London by the different water companies as a stream 9 feet wide and 3 feet deep, flowing with a velocity of two miles an hour; a supply double the actual consumption. In the course of my exploration I could not fail to observe that such a volume of water of any quality was nowhere to be seen, which at first rather damped my hopes for the future; but I remembered that such a body might be made up by collecting the smallest threads of rivulets, and went on my way. To effect this then was my object.

A most minute inspection of the gathering grounds has shown me that their nature exactly adapts them for the means of collection proposed by the Board, namely, a system of thorough drainage. A more admirable plan of gathering rain-fall could not have been conceived; the sands, acting as a natural filter, deprive the water on its passage to the pipes of any impurity contracted either in the air or in percolating through the upper crust; as, for instance, where the water might be discoloured by peat, experiments have proved that the sands restore its primitive colour, and deprive it also of the flavour imparted by the peat. The heath, which covers the entire area of the gathering-grounds, also stains the water, but the impurity is removed by this process of natural filtration. I would remark, that the discolouration visible in the stream called the Blackwater, is not caused by peat, but by the heath and loose black loamy nature of the soil through which it flows. This I have proved, by following up its various sources, one of which only, at Cove, passes over peat. Samples of springs rising in peaty bogs, show no discolouration whatever, but are as clear as water issuing from sands.

Remembering Farnham-hill, I turned my attention to look for springs, and, after much and close examination, came to the conclusion that the origin of many little silver threads of water, silently stealing down the hill sides under the grass, arose also from such sources. A diligent search showed me that the quantity of water to be derived in this manner within the original area of the gathering-grounds is so great, that if the neighbouring ranges of mountains and hills on the south side—namely, Hindhead, Blackdown, Hascombe-hills, Leith-hill, &c., presented the same feature, I might probably hope to collect a stream 9 feet wide and 3 feet deep, of the desired softness and purity.

I am now happy to inform the Board, that a month's researches into every hill and glen, every copse and crevice, has produced this result. Having tested the waters as they issue from their sources, I can announce that I have gauged a sufficient number of springs and rivulets to enable me to form an opinion both as to quantity and quality; the water being of its primitive purity, perfect as to aëration, brilliant in colour, soft almost as distilled water, of a grateful temperature, about 50°, and almost free from all mineral, animal, and vegetable impregnation. In a future section of this report, I hope to be able to give the Board more extended information on this point, as also with reference to the levels of the springs above mean tide. Thus, by gauging and testing the streams at their sources, instead of in their course and outfalls, we have the realisation of the principle laid down by the Board; and this difference will account for the variance of my results with those of Dr. Angus Smith.

The annexed table of springs and rivulets gives their hardness, according to Dr. Clarke's soap test, their daily discharge, and the number of houses they are equivalent to at 75 gallons per house; an addition of one-half the average domestic consumption, as proved by an experiment instituted in the district of Earl-street, London, on a block of 1200 houses of a fair average class, the gaugings of the sewer gave 44½ gallons, and of the butts and cisterns, 51½ gallons per house.

TABLE *of Springs and Rivulets, showing their hardness, daily discharge, and the number of houses each is equivalent to, at the rate of 75 gallons per house.*

Names.	Degrees of Hardness.	Gallons discharged per day.	Houses at 75 gallons per house.
Hindhead and Blackdown[1] :—			
Holy-water	2	1,356,000	18,000
Bramshot[2]	1½	13,399,714	178,622
Down-lands	1	540,000	7,200
Headley-down	1	239,731	3,197
Barford-mills	1	3,880,000	38,400
Devil's-jumps	2	360,000	15,000
Punchbowl	1	299,995	3,999
Cosford-house	1	674,928	8,999
Gray's-wood	1	84,240	1,123
Kotchet	1	32,568	434
Five other springs	1	127,562	1,700
Hascombe-hills[3] :—			
Sweetwater-pond..	1	1,066,795	14,223
Bush-bridge	2	529,200	7,056
Chapel-copse	2	224,697	2,955
Hascombe	2	229,116	3,988
Leith-hills[4] .—			
Totsford	2	1,799,798	23,977
Watton	2	890,956	11,879
Rookery	2	1,436,400	19,532
Easthampstead Plain :—			
Wishmoor	1	388,308	5,177
Broad-moor	1	176,840	2,347
Sandhurst	1	54,000	720
Ambarrow-hill	1	75,888	1,011
Barkham	1	101,088	1,347
Wokingham	1	599,904	7,998
Bull-brook	1	113,320	1,497
Chobham-ridges :—			
Pirbright	1	810,000	10,800
Railway	1	460,000	6,134
Cow-moor	1	90,435	1,285
Coldingley	1	758,160	10,108
Folly	1	256,492	3,419
Bagshot	1	630,060	8,400
Bristow-farm	1	14,999	199
Farnham :—			
Aqueduct	1	45,848	584
Minley	1	134,928	1,798
Northfleet	1	6,426,000	85,650
Longbottom	1	31,809	424
Bramshill	1	43,372	578
Eversley	1	74,779	997
Castle-bottom	1	270,000	3,600
North :—			
Farnham-hill	1	685,454	8,739
Total............	..	39,407,324	523,156

[1] Will be led away at one degree of hardness.

[2] One and a-half degrees under the mill-wheel; but will probably be led away at half a degree of hardness.

[3] Will be taken away at half a degree of hardness.

[4] Will be led away at one degree of hardness.

Giving altogether 39½ millions of gallons, which might be brought to London at a hardness certainly not exceeding one degree. I can answer for at least 10 millions more under two degrees of hardness. I must remark, that though these gaugings are only offered as an approximation, I consider they will eventually prove to be rather under than over-stated.

I would remark that, where the springs flow into ponds dammed up for the use of mills, I have taken the samples for tests from the springs themselves, as the evaporation alone of large surfaces of water generally adds two and upwards degrees of hardness, and the waters are also exposed to deterioration in colour, and, as I have found, in taste. For instance, at Minley Pond, itself situated between sand-hills, the springs do not show half a degree of hardness, the pond one and a half; at Sweetwater Pond the springs have half a degree of hardness, the pond two degrees; at Bush-bridge the springs have one degree of hardness, the pond nearly six.

I would here remark, that an erroneous opinion seems to prevail generally that large bodies of water should be examined for test of quality, which, in proportion to their size alone, show a scale of hardness contracted in their passage through loamy or other soils. Hitherto the little springs rising in pure sands, scarcely seen under the herbage, have been almost entirely disregarded, although when gathered together they form a volume equal in extent to that collected on the lower levels, and of a purity and softness in no case to be found there.

The gaugings of these springs having been taken at the end of a drought of nearly five weeks, and at the close of an average dry summer, I conceive they are to be relied on with safety, as being at their usual summer ebb. Being a perfect stranger to the district, and of course obliged to depend very much on the testimony of the residents as to the flow of the springs, I have addressed myself to persons of all classes, gentry, farmers, and labourers, many of whom have resided all their lives on the same spot, and are therefore well able to offer an opinion. I received much valuable information from an herb doctor, who devotes his sole attention to wounds and sores, and finds his remedies in herbs and grasses, many of which grow in water, by which means he had come to the knowledge of these springs. The unanimous opinion of all observing persons is, that I gauged these springs at their lowest. I am convinced that the greater mass of them are, as at Farnham-hill, due to rain-fall elsewhere, probably on ranges of equal and higher levels, at a considerable distance, where the nature of the strata will not permit of the rain-fall making its appearance again after percolation; the water then finds its level, and an easy channel through the sands of the gathering grounds. I attribute the fact of the springs invariably coming out under the highest and steepest bank of the hills to the circumstance, that such is the only place where on that contour there is not the usual densely-packed covering of gravel, through which they would scarcely penetrate when there is an easier outlet. The steepness of the bank itself is apparently caused by the undermining action of the springs.

My opinion of the unfailing yield of these springs is confirmed by the peasants, who in several instances have of their own accord informed me that at the close of autumn, generally in October, when there has been no rain in this district, the springs commence rising just after a high wind. They offer no explanation of this apparently extraordinary circumstance, which to me, however, admits of easy explanation; the high wind being possibly a fortuitous circumstance, but probably indicating a storm of rain and wind elsewhere, where the strata are of the formation alluded to.

Droughts of much longer duration than five weeks seldom occur, and, should they do so, the yield of the springs is so far in excess of the present requirements of the metropolis, that there is little foundation for any apprehension of scarcity.

To detect the presence of these springs in combination with other waters was in some cases very easy, as where the residents are acquainted with them, or where they are so large as to thrust themselves on one's view; but often they have nearly eluded my most vigilant scrutiny. Situated in the hollows of the hills, generally collections of rainwater are to be found, girt sometimes by dense copses with rushes and long-tangled grass. The marshy appearance of the ground on the lower side might, by a casual observer, be taken for the soakage of the pond; but if a trench be dug to the outfall the run is found to be constant, proving the presence of springs flowing into or rising in the ponds themselves. On one occasion, on questioning an intelligent labourer, he remarked that, when bathing in Minley-pond, he found the water at some parts much colder than others, and was at a loss to account for the circumstance, which clearly indicated the position of the springs, as I found the outfall to exceed the flow into the pond.

So secluded are some of these sources, that their existence on one occasion, at Chapel-copse, only became known to a *soi-disant* gamekeeper (but, from his appearance, I fear, a poacher occasionally), by the flight of game to drink there after dawn. This spring yields 224,697 gallons per day, equal to the supply of 2995 houses, and forms one of the many threads contributing to the desired supply. I am further of opinion, in which I am confirmed by all the residents, that these springs will, when opened—that is, given a free passage to the surface, often be doubled in volume; indeed, this has, on several occasions, been proved to be the case by paper manufacturers and others who have been anxious to increase their supply; as, for instance, at Barford Mills, where some years ago the paper-mill could only work for three or four hours a-day, but the spring having been opened now affords a sufficient supply for six hours' work. I have tested these waters, and all others in the district, including wells, and those from the surface, at different stages, as where joined by fresh tributaries, or entering a new soil, from their outfall to their sources, and the result has been very decisive in confirming the remark made by Professor Way, in his able paper on *The Power of Soils to absorb Manure*, 'that ordinary soils consist of three substances, sand, clay, and vegetable matter, but that very generally a fourth may be added, carbonate of lime.' When these springs rise in any other than pure sands, the water at once becomes hard to five or six degrees. If in any case I believed a stream to have a very pure source, I proceeded up its course, examining it at the junction of each tributary, and have never failed in discovering at length, and generally from the highest source, the thread of soft and sweet water to be added to the growing stream for water supply.

Let me point out the following, for example,—

	Degrees.
The Wey, at Guildford, which has a hardness of ..	9
At Elstead	8
Below the junction of the Bramshot river	9
Above the junction of the Farnham branch	6
Above the junction on the Bramshot branch ..	14
At Farnham	15
But turning up the Bramshot river at Headley Wood ..	5
At Bramshot	1¼
At Shotter Mill	⅛

The above shows what different results two persons making the same investigations might arrive at. From Headley-wood to Bramshot is scarcely more than two miles; persons unintentionally, or for want of accurate investigation, might consider the water at Headley-wood the sample of greatest purity to be found, and go away with and disseminate a totally false impression. I have reason to believe it will be generally found that the opponents to the Board's proposition have, from one cause or the other, made this great mistake.

The power of soils in hardening water is particularly evident when comparing the water in a large pond to that in a well, which becomes hard almost in proportion to its depth. A notable instance occurs at Tomlin's Pond, a collection of rain water with a few small springs in it, which has a hardness of only 2 degrees; whereas, a well sunk close by for the convenience of some cottagers has a hardness of 5¼ degrees. Again, Minley Pond has a hardness of only 1⅛ degrees, while a well, sunk through the loam into the pure sand, has 3 degrees of hardness.

The following is a list of well and surface waters, with their degrees of hardness:—

Wells.

	Degrees.
Hartford-bridge Flats, 25 feet deep	4⅛
Ash-common, 80 feet deep	6⅛
Pirbright-common, 20 feet deep	5
Chobham Well	5
Swinley-cottage, Easthampstead-plain	5¼

Surface Waters.

Ash-Common	3¼
Holt-pond	2¼
Dippenhall	3⅛
Whitemoor	3⅛
Aldershot	1⅛
Canal, Reading-road bridge	5⅛

Thus we see that waters stand for purity in this district in the following order:—1. Springs issuing from pure sands.—2. Collections of rain water.—3. Water running through ordinary loamy soils.—4. Well waters.

How great is the loss of capital and labour expended on wells, which when made, what has been done? A vast expense is incurred to dig a hole in the ground to allow water to soak into impure from the mineral qualities of the soil; what water?—that which fell originally soft and pure, and which might have been collected on roofs, or by drainage of cultivated lands and led into a covered reservoir, and thence to the highest room in the house. One gentleman with whom I am acquainted spent from 300*l.* to 400*l.* in sinking a well 300 feet deep, whence he obtained water of a hardness equal to that of London. 400*l.* would have drained from 40 to 50 acres of his land and paid for a covered reservoir, besides saving the labour of pumping and carrying, the waste of the latter in the case of using 75 gallons per day per house, amounting to a loss of three days' labour of one person in a week. The improvement of the land drained would alone have repaid the outlay.

A great economy in having water laid on to the top of a house exists from the indolent propensities of servants. Should there be two supplies, one of soft water, and another of hard nearer the premises, the servants will, I have frequently found, to save trouble, use the latter for all purposes, thus extravagantly wasting their masters' tea and soap; the saving in the consumption of which with soft water would soon have paid the cost of laying pipes into every part of the house.

I would point out the defects of storage reservoirs on gathering grounds as now existing in some parts of this country. They collect the crude surface waters, always liable to discolouration and thickening from dirt brought in by heavy rains, to deterioration in taste, to hardness from contact with the soil, as also by evaporation; this last, however, being trifling as compared with the first, as we have already shown. Compare these results with the proposition of the Board. After the ground is once saturated, the rain-fall passes immediately through a natural filter of sand into the drainage pipes, which lead it away to storage reservoirs lined with tiles to prevent the water acquiring the mineral qualities of the soil, hence to a covered reservoir in the neighbourhood of its distribution, safe from the noxious influence of the impure atmosphere of a city. The importance of covered reservoirs cannot be overrated when the evidence given by several eminent professors of chymistry before the Board is considered, although little more than every day's experience is needed to show that what is disagreeable on a small scale must be very detrimental, often dangerous, in larger volumes of water. A tumbler of water cannot be exposed half an hour without becoming warm, vapid, and badly tasted; and from what cause? Simply because water has an extraordinary capacity for absorbing the impurities of the atmosphere.

Referring again to the plan of collecting rain-fall by draining the sandy heaths, I question whether it could in one case be carried out with advantage—namely, on the higher levels; as, for instance, the crests of the Fox Hills and Chobham Ridges, where the strata of sand are of a very loose nature. I think that the surface once broken through, the water would pass by the pipes. The area on which this would happen is, however, not very large. It is very desirable to ascertain this point by trial works; a few acres drained would satisfactorily settle an important question. The same would occur in the lower levels were it not that nature has abundantly provided a subsoil in the form of a crust or pan about 9 inches thick, composed of 3 inches of closely-packed pebbles and sand resting upon 6 inches of sandstone. This pan lies at a depth varying from 1 to 3 feet below the surface; in some cases it is found beneath a few inches of sandy loam. The pipes might be laid on the pebbles and sand incrusted together, which would hold the water. The pan once broken through the water would, I fear, be lost for ever. The cultivation of these heaths would eventually repay a large portion of the expense of collecting a rain-fall by drainage. Mr. Hewett, a most intelligent farmér and land surveyor, from whom I have obtained much valuable information, assures me that where this pan comes near enough to the surface to be broken through, which is done at an expense of 8*l.* or 10*l.* per acre, and when properly manured, the cultivation pays.

The only disadvantage attending the Board's scheme, if in such an important matter it may be deemed so, is the expense of the large lined storage reservoirs necessary to contain a six weeks' or two months' supply for a city of the giant proportions of London; otherwise the system is unique in simplicity and perfect adaptation for the purpose required. So vivid was this impression on my mind, that on developing the idea of supply from springs, I conceived a method of adapting the principle to my own case. Where the springs are large, I propose to inclose them in brick or tiles, but when small and numerous I would prefer to gather them in one stream to be led away in pipes; but this must be effected on the pure sand, and great care must be taken to avoid the mixture of surface-washing. In the case when leading away a stream of springs it would be liable to discoloration from heavy rains, I propose to provide a remedy by preparing at the point of diversion from the natural channel a new bed for a short distance at a less inclination. The bed to be a trench with a pipe at the bottom, and filled up with small stones and sand, heather or heath being placed round the pipe joints. The stream being led on this new bed will percolate into the pipe beneath. When the extent of the ground above the springs would expose them to be choked up by rubbish and dirt after a storm, I would intercept the rain-fall in contour trenches with pipes underneath them also, and lay a branch to lead the water away to the main. I have shown both these plans as adapted to the case of Farnham-hill, and a large addition might thus be made to the flow of the springs if desirable.

Hereafter I propose to detail my arrangements of branch lines from the spring-heads, leading to mains terminating on Wimbledon-common; giving also an estimate of the expense of the entire schemeworks, compensation to mills, &c., also some general information on the collateral advantages of a pure soft water supply—the results of some experiments I am making on the action of sand as a filter, and some qualitative analyses of the springs.

The annexed plan is that of Farnham-hill, reduced from the Tithe Commission plan, and tested as to accuracy. The blue contour line represents the level of the springs. I have gathered them together and gauged their flow as accurately as in my power. Their daily discharge is equal to 897,393 gallons.

The area within the contour line is 571 acres. The available rain-fall from 22·65 inches per annum; a mean of 30 years' register at the Military College, Sandhurst, allowing the usual deduction of 14 inches for evaporation and absorption, is 279,858 gallons per day. The difference, then, 611,160 gallons, is the least figure in favour of my assertion that the water in this hill is due to rain-fall elsewhere, for the rain on the hill does not percolate, but passes away.

I assure the Board, however, that a careful collection of these springs would double their volume, and produce a daily discharge of 1,794,786 gallons. This, then, leaves a total of 1,514,928 gallons above the available rain-fall on the hill, supposing it all to penetrate. The plan also shows the hill drained above the springs on the principle already alluded to. The section of the pipes and their outfall is calculated in proportion to the quantity of rain likely to fall in the shortest time, according to the principle laid down by Mr. Chadwick.

In reference to my idea of the cause to which these springs are due, I would mention that a notable instance of the kind occurs in Hongkong, an island mountain of not 25 miles in circumference at its base, and of 1000 or 12,000 feet elevation above the level of the sea. The quantity of water supplied from springs on the top of this mountain is notoriously far beyond its rain-fall, which latter, from the declivity of the other ground, is at once discharged into the sea, as all who have been there are well aware of. The shore of the mainland is not further than two miles and a-half, but the range of mountains of equal and higher elevation, and which furnish the supply, are at a distance of upwards of ten miles. The rain-fall cannot find its way again after percolation to the surface, and is necessitated to find its level by crossing the sea and rising through the fissures of the granite formation of Hongkong. The springs are rarely known to be affected in quantity even after a three months' drought in the island, the thermometer often at 80° and upwards in the shade.

The advantages I propose to derive from permanent springs, that is, always preserving an average flow of summer and winter, over surface drainage, are twofold:—

1. The continuous flow from springs gives water of better quality as to aëration and temperature.

2. An immense saving will be effected on the item of storage reservoirs, and, I believe, a considerable sum in the diminished quantity of excavation and pipage. Assuming that the supplies from these springs do not materially alter, no necessity can exist for storage reservoirs. A covered reservoir for two days' supply might be provided at Wimbledon-common to meet any extraordinary emergency; otherwise, a main with a simple waste-pipe into the Thames would suffice.

Too much importance cannot be attached to a constant flow of pure, cool, and soft water, brought direct without detention from the Hindhead to the attic of the highest house in London. How grateful will be the daily use of cool soft water only 24 hours from a natural reservoir in the depth of the earth!

I consider I have realised, in a remarkable manner, the Board's enunciation —"The nearer the source the purer the supply." The whole value of the scheme appears to me to depend on the accurate following-up of this principle.

On consideration of the original proposal, there is only one more point I shall at present touch upon—namely, the great and scarcely estimable benefits of land drainage, not only to the soil, but to the inhabitants of the district. From the rain-fall, a depth in the year of 22·65 inches (allowing seven to be absorbed), there remains nearly 15 inches, or 1529 tons of water on every acre, impeding cultivation by diminishing the temperature of the soil, by not allowing a proper circulation of air in it, and by causing a perpetual evaporation, not only injurious to health in itself, but excessively wasteful of the heat of the atmosphere, a loss which in our damp climate is a very serious consideration indeed; and it is only when the whole country shall have been perfectly drained that this stigma of unnecessary and dangerous damp will be effaced from our registers of temperature.

Again, experience has satisfactorily shown (*vide* the Report on the Water Supply) that the low temperature of undrained land is the chief cause of scanty and poor crops, and inferior growth of timber. In an economical point of view, it is most necessary then to remove this noxious agency.

Having given the results of my observations in detail, it may be now proper that I should state my opinion of their variance as compared with the conclusions enumerated in the report, which difference I attribute to the limited investigation of the subject.

Generally, in all points as applied to the quality of water, its advantages in economy, its beneficial influence on health, &c., my experience not only distinctly confirms the views of the Board, but has elicited further illustrations, in respect to which I hope shortly to have the honour of addressing them. This information I have collected from persons of all classes, medical men, manufacturers, farmers, tradesmen, peasants, &c., all of whom, in their different spheres, have given me valuable evidence on the subject in question.

The results of my experience are as follows:—

I. With respect to the quantity and quality of water to be derived from the gathering-grounds, in whatever method of collection—the report gives 28,000,000 of and under three degrees of hardness. My results give 40,000,000 of and under one degree, and 10,000,000 of and under two degrees of hardness. This improved quality is gained by my development of the principle of taking the water from its source (that is, where it issues from pure sands), and leading it away before it can be affected by contact with soils. I beg to express my conviction that the purity will depend entirely on the careful execution of the work; it would give, to recapitulate its qualities, 40,000,000 of water, of primitive purity; perfect as to aëration; of a grateful temperature, about 50 degrees; brilliant in colour; soft almost as distilled water; and almost free from all mineral, animal, and vegetable impregnation, sufficing for the supply, at the estimate of 75 gallons per house, of 523,156 houses.—The 10,000,000 of and under two degrees of hardness are derivable from sources rising in sands not quite pure.

II. By the direct means of collection from springs, instead of the extensive system of land drainage originally contemplated, very considerable saving of expense would be effected:—1. In the less quantity of pipage required, and, consequently, of labour expended. 2. On the item of the large extent of storage reservoirs, originally required to provide for summer months, periods of drought; and which, by my plan, would be unnecessary. 3. On the reduced claims for compensation, especially as no breadth of land would be required to be taken up. In fact, after collection, on descending into the lower levels, the mains would lead along and just outside the lines of railway. A mere underground right of way—a pipe-laying easement—would be required.

A *résumé* of the above then gives, in favour of the plan proposed—1. Greater certainty of supply. 2. Superior quality. 3. Greater abundance. 4. Greater speed of execution of work and application for service. 5. Greater economy.

Should the future exigencies of the metropolis require an increased supply, it may still be derived not only from land drainage of rain-fall on the pure sands beneath the level of the sources now proposed, but also to a great extent above them.

In conclusion, I would remark that it might be considered desirable to allow the towns of Guildford, Richmond, &c., and the different villages on the line of water supply to London, to partake of the advantages proposed for that city. The first of these suffers severely from hard and expensive water. Of course they would have to pay their proportion of the rate to be levied to meet the expense of the works, which I hope shortly to be able to show will not, for an increased, continuous, pure supply of soft water, at high pressure, exceed a fraction of the sum now levied by the water companies for an impure, hard, and defective one.

I have the honour to be, my Lords and Gentlemen,

Yours obediently,

William Napier.

The General Board of Health, Gwydyr-house, Whitehall.

IMPROVEMENT OF THE TOWN OF LIVERPOOL.

In June last, the council advertised for plans for the improvement of the streets and approaches of the town, and the laying out of the unoccupied lands in its immediate vicinity, offering a premium of 50*l.* for the best one, and 25*l.* for the second in point of merit. By the end of August, twenty-three plans, with explanations, were sent in, all of which are now on view in the Council Chamber. The first premium was awarded to Mr. H. P. Horner, who adopted the motto of "Rus in Urbe," and the second to Mr. Henderson, "Curator." Both gentlemen are architects practising in that town. The suggestions and plans were submitted at the last meeting of the council.

Mr. Horner's Plans.

"In submitting the suggestions indicated on the accompanying plans, I should wish, in explanation of what may at first sight appear the rather sweeping character of some of them, to mention the general idea under which they were laid down, viz., that taking the terms of the requisition in their fullest sense, I should endeavour to form such a plan as would serve for my own guidance, supposing myself responsible for the *progressive* improvement of the town and its environs to the greatest extent which circumstances might successively permit.

"Such a plan, prepared with the most mature study, and revised from time to time, should, in my opinion, be kept by every public officer under such responsibility with respect to any large town, in order that the conclusions as to what would be desirable, when possible, might not be lost sight of, but, as leases fell in, buildings were removed, or land brought to sale, such opportunities might be seized for the improvement of thoroughfares, and such other alterations as would conduce to the convenience and comfort of the inhabitants.

"The general aspect of Liverpool presents several obvious points for the application of such a system of persisting improvement, as few large towns bear more distinct marks of having been laid out with little view to the probability of its increase, and in few have more opportunities been missed of correcting original errors at later periods of its progress.

"Among the most striking defects in these respects are to be observed the cutting off of leading thoroughfares at particular points, as if never to be extended, and sometimes closing them with a public building—a church and its burial ground for example—with perhaps a long cross street behind it, affording, for a great distance, no outlet in the direction of the main street.

"Again, we find that the districts to the extreme north and south have been laid out almost without reference to their connection with the centre, forming distinct systems of streets within themselves, with in each but one main connecting thoroughfare with the central part of the town, and that adopted only as following the tortuous course of an ancient roadway.

"Further, we may notice that the natural and easy method of gaining a summit by traversing its ascent in a diagonal line, has been lost sight of, and a steep rise breasted at a right angle, and at the same time communication made more difficult and tedious by series of streets traversing the length of the slope, with such frequent interruptions of line as to disfigure, and, to appearance, contract the extent of the town to an extraordinary degree. The crowning evil consists in the manner in which purchasers of land in the outskirts appear to been allowed to lay out their streets on any plan (or no plan) as might suit their own fancy and ignorance, causing irremediable confusion when the intervening space comes to be filled up, and increasing in a tenfold degree the almost necessary ugliness and discomfort attendant on the existence of that space of debateable ground between town and country which commonly surround an increasing and populous town.

"One or more of these considerations will be found to have led to the adoption of the several proposed alterations shown in my town-plan, in addition to the wish to open out some public buildings (now scarcely to be seen but on a close approach), and to give an increased number and length of vistas—points on which beauty and magnificence of effect in towns confessedly depend.

"As regards the approaches, my attention has been mainly directed to the connection of roadways at present detached, straightening those which are inconveniently crooked, providing for their probable communication with existing or proposed streets, and, above all, securing one of the best provisions for the *comfort and health* of an immense population, *a belt of garden or park land* bounding the present extent of the town, and insuring the interposition of a stretch of comparative *country* between the existing buildings and any more of a *town* character which may be needed in after times for the growing community.

"It is satisfactory to know that the corporation have of late years taken decided steps towards this last most necessary object, while the liberality of one generous man has set an excellent example in the same direction. Much, however, remains to be done, and it is with the hope of calling attention to the point that I have, so far as circumstances permitted me, shown how I think many tracts of, as yet, unoccupied land, may be made available for the use and recreation of all classes.

"The boulevards of Paris and other continental towns are acknowledged as greatly conducive to sanitary ends, and the subject, as is well known, has been taken up with much energy in London, where the feeling now prevails to secure for this purpose as much as may be of what land is still open; though the manner in which the town has been allowed to extend without this wholesome interruption throws great difficulties in the way, as will be the case in Liverpool, if speedy steps are not taken in the matter.

"The health of the population would, in addition, be benefitted by the opening up of lines of street terminating at the quays, and unobstructed by warehouses on the dock sides; and some such streets, crossing the rise of the hill *diagonally*, I have shown on my plan, and I do not know a point in which more has been lost to the good of the town, (through want of a better system of forming the streets,) than this important one of ventilation by long vistas from the river.

"Before referring *seriatim* to the several projects included in my scheme, I would observe that the legal powers required for such improvements can scarcely be less readily granted than for others of a more extensive and less benevolent character; while the difficulties which might be anticipated in gaining the co-operation of the large owners of land, involved in these changes, are to be met by the considerations of mutual benefit, which may safely be urged in their favour.

"The distinction between corporation and other property being scarcely traceable (in the plans furnished) even in the suburbs, and not at all within the town, the suggested alterations could not be guided by them, nor, it is presumed, was it expected that contributors of designs should enter into such particulars, as the labour and expense attending the necessary inquiry would have been such as to deter many from competing."

The report then details 22 suggestions for the improvements of the town, and for the formation or enlargement of eight parks in the environs.

"In conclusion, I would observe that, though the space of ground occupied by the proposed parks appears great, it must be remembered that their formation would necessarily be extended over a considerable period of time, and in our climate, and so near the sea, single rows or avenues of trees will never thrive in the same degree as shrubs and plantations will, which naturally shelter and protect each other from our cold winds.

"The strong probability that the town will eventually extend itself in length along the river rather than in breadth (crossing the natural boundary formed by the ridge to the east), has also led me to confine my proposal to this line of garden land as best suited to English tastes and habits.

"Rus in Urbe."

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

The first general meeting of the Institute, after the recess, was held on November 4th, at the rooms of the Institute, in Lower Grosvenor-street. In the absence of Earl de Grey, the president, the chair was taken by Mr. Fowler, one of the vice-presidents, who in congratulating the members upon their meeting together again, mentioned, in reference to the prospects of the ensuing session, the Great Exhibition of 1851—an event which could not fail to be of the greatest interest to the Institute of Architects. It would, doubtless, bring to this country a large number of the distinguished men of science abroad, the names of some of whom were enrolled in their lists as honorary and corresponding members; and the council had not forgotten to take into consideration arrangements to give their expected visitors a befitting and cordial reception.

Professor Donaldson, the corresponding secretary, in laying upon the table a collection of works presented to the Institute during the recess, likewise made a particular reference to 'Suggestions for the Improvement of the Lord Mayor's Show', by Mr. George Godwin. In alluding to useful communications, Professor Donaldson expressed his gratification that a French translation had been officially made of the paper read to the Institute last session by Mr. Henry Roberts upon "the Improvement of the Dwellings of the Labouring Poor." (*Des Habitations des Classes Ouvriers; traduit et publié par ordre du President de la République: Ministère de l'Agriculture et du Commerce.* 1850.) He dwelt upon this as a fact which proved the government of France was very prudently turning its attention to the sanitary and social condition of the working classes.

Mr. James Bell, Fellow of the Institute, read a paper "On the Remains of the Architecture of the Roman Provinces," which we have given in full at page 378.

INSTITUTION OF CIVIL ENGINEERS.

Nov. 12.—William Cubitt, Esq., President, in the Chair.

The following paper was read :—

A comparative view of the recorded Explosions in Coal Mines. By Mr. William West (of Leeds), Assoc. Inst. C.E.

The Reports of Faraday, Lyell, De la Beche, Playfair, and others, were carefully analysed and tabulated, from which it appeared that tendencies towards a dangerous condition existed in mines reputed to be comparatively safe, and that these tendencies were so numerous, and varied so suddenly in their nature and extent, as to necessitate attention to every kind of precaution.

The proposed appointment, by the government, of Inspectors of Mines, was noticed, not with the intention of showing that their supervision would diminish the responsibility of the mining engineers and overmen, but of demonstrating, that by establishing more constant communication between the various districts, they might induce the general adoption of those measures of precaution which were found in certain mines to be so efficacious in averting accidents, or in affording means of safety when they did occur.

The different depths of mines, varying from seventy-five yards at Darley, to three hundred yards at Haswell, did not appear to have any influence on the accidents. The tendency to the emission of carburetted hydrogen gas from certain seams, would have appeared a more rational reason, though the records did not appear to bear out that theory, as mines receiving a tolerable character, had been the scene of repeated explosions; for instance, the Jarrow Mine, where, although reported "to be not very fiery," there had been six explosions in the course of twenty-eight years, and one hundred and forty persons had been killed.

The compatibility of general good ventilation, with the occasional occurrence of the most fatal explosions, was particularly dwelt on. The witnesses on the inquests after the Haswell and the Jarrow accidents, agreed that the "ventilation was perfect," "the pit full of air," and "the air quite good, and plenty of it." The fault, then, did not lie in the quantity of air, but rather in the difficulty of directing it so generally throughout all parts of the mine, as to sweep away the gas as it was produced. The "splits," for the air were noticed, and the condition of the goaf, the pockets of gas formed in the roof, and the sudden irruptions from the occasional falls in the goaf and old stalls, were dwelt on at great length, and, combined with the injudicious use of unprotected lights, and liability of accident to the lamps, were shown to have been the probable cause of all the explosions. The miners' lamps were passed over somewhat too cursorily, as at the present moment, when so much has been done for their improvement, that part of the subject might have been descanted on with advantage.

The precautions for saving life on the occurrence of accidents, such as abolishing bratticed shafts, and sinking a pair at each mine, at such distances apart as should ensure one remaining intact, incase of an explosion injuring the other; the "scaling off" of a portion of the fresh air for the exhausting furnace, and conducting the return air into the upcast shaft at some height above the fire; together with several minor details for insuring the constant working of the exhausting apparatus, to draw off the fatal "after-damp, or choke-damp," were strongly insisted on.

The rashness and carelessness of the miners was instanced on with regret; but it was shown that by education and good example, their better qualities must be brought out, and that then, the best safeguard against accident would be the instinctive love of life, and a knowledge of impending danger from the infringement of any of the precautionary regulations established in the mines. The improvement of the workmen was, therefore, strongly insisted on, as more real benefit would probably result from such measures, than from the appointment of a host of government inspectors.

The paper was illustrated by large diagrams of the author's views of the forms of "goaf hollows" and "goaf basons," as well as by several plans of mines, &c.

The President reminded those gentlemen who had recently joined the Institution, of the engagement they had entered into, to present original communications, or drawings, &c., and urged upon the members of all classes the necessity of furnishing good papers, so that the interest of the meetings might be sustained, and the usual discussions be promoted.

Nov. 19.—William Cubitt, Esq., President, in the Chair.

The subject of the paper read was "*The Ventilation of Collieries, theoretically and practically considered.*" By William Price Struve, (of Swansea), M. Inst. C.E.

The author commenced by showing that the general principles which ought to govern the ventilation of collieries, were—

1st. That a current of air through the channels of collieries, at a velocity of five feet per second, was sufficient for most purposes.

2nd. That a current exceeding that velocity would only be attained a the expense of leakage and other evils.

3rd. That in order to obtain the requisite supply of fresh air, the channels of a colliery or mine ought to be enlarged, according to the exigency.

In the process of laying out a mine, a subdivision occurred by which the workings were apportioned into numerous compartments, which facilitated the system of splitting the current of air, or diverting it into numerous channels, giving to each compartment a separate, and, therefore, more effective ventilating force; at the same time the area of the channel was enlarged, and the aggregate length of the air tube shortened, so that it was quite practicable to pass through the workings of a mine 300 cubic feet of air per minute for each man employed.

The velocity of the air current in a mine was so easily affected, that it was important to consider by what accidents, and under what circumstances, any changes took place.

It could not be supposed that the excavated space of old workings was completely filled by the "falls" of the roof and "creeps" of the floor; extensive rupture of the stratification occurred, and through this broken ground great leakage must take place. This would seriously affect a long continuous air course, therefore, the way to meet this difficulty was to split, shorten, and enlarge the air channel. The details of two experiments at the Eaglesbush and Yuis David Collieries, where the air was pumped out by Mr. Struvé's Mine Ventilator, showed that a large proportion of the air was drawn from the old workings, and the "goaf," or broken ground surrounding the colliery, and did not come down the intake shaft, and traverse the actual workings, as it ought to have done.

In both these cases, the enlarging and splitting of the air channels, so as to reduce the velocity of the air to about three feet or four feet per second, would have produced most beneficial results.

These principles were shown to have been lost sight of in the majority even of the great collieries, and the power of rarefaction by a furnace was trusted to for dragging the long column of air over and through innumerable impediments. In some cases this was left to be produced by the increased temperature of the mine, from the candles, and the respiration of the men, aided by the cooling effect of water trickling down the intake shaft. These scarcely sufficed to produce an average difference between the two shafts of thirteen degrees in winter, whilst in the summer, and in certain states of the atmosphere there was no difference at all, and, consequently, little or no ventilation. Where rarefaction by heat was used, the temperature in the upcast shaft varied from ninety degrees to one hundred and sixty degrees; this, however advantageous for ventilation, was injurious to the shaft itself, and absolutely dangerous to the men who had to traverse it.

A comparison of the dimensions of the air passages and the velocities of the currents in numerous collieries, led to an estimate of the motive power required to produce the results attained in the best ventilated mines, in case of the employment of a steam-engine and air-pumps. This power would have varied between 23-horse power and 26 horse power.

The efficiency of furnace ventilation was always increased by the depth of the shafts, especially if they were entirely devoted for the purposes of ventilation, irrespective of the working of the pit.

The experiments of Mr. Nicholas Wood, Mr. G. Elliot, Mr. H. Vivian, and other mining engineers, were then quoted, to demonstrate the insufficiency of the "steam jet," as a means of promoting ventilation, showing that it was a most wasteful application of power, when compared with the steam force employed to work Struvé's Mine Ventilator at the Eaglesbush Colliery. This apparatus consisted of two hollow pistons, resembling large gasometers plunging into cisterns of water, and having inlet and outlet valves. The pistons received alternate motion from a small steam-engine of 5-horse power; and being filled and emptied at each revolution of the crank, produced a regularity of current and a degree of copious ventilation hitherto unknown in the mines to which they had been applied. The small cost of their establishment—only about one hundred pounds for an extensive mine—joined with the little liability to getting out of order, was much in their favour.

The paper terminated with copious extracts from the able mining reports of Mr. John Phillips and Mr. Kenyon Blackwell, confirming all the positions assumed by the author.

Nov. 26.—The discussion upon Mr. Struvé's paper occupied the whole of this evening, and will be resumed on Tuesday, December 3rd.

We understand that a Telford medal in silver has been awarded to G. B. Thorneycroft, Esq., of Wolverhampton, by the council of the Institution of Civil Engineers, for his paper "On the manufacture of malleable iron, and on the strength of railway axles," read during the session of 1849-50. The medal will be presented at the annual meeting on Tuesday evening, the 17th of December next.

ROYAL SCOTTISH SOCIETY OF ARTS.

This Society commenced its annual sittings on the 11th ult., in its new and commodious hall, George Street, when Thomas Grainger, Esq., C.E., the President, opened the session by an eloquent address.

The following Paper was read:—

"*An Account of the Chimney of the Edinburgh Gas-Works, with Observations on the Principles of its Strength and Stability.* By George Buchanan, Esq., F.R.S.E., C.E.

In Part I. of this paper Mr. Buchanan gave a very interesting account of this remarkable structure, and the principles of its strength and stability. It was one of the works particularly alluded to by the President in his interesting introductory address last year, and of which he thought it important that the Society should have some account; and Mr. B. having been professionally connected with the work, had much pleasure, at the President's request, in now stating what he knew of it. Having communicated also on the subject with the Gas Company, Mr. Watson, the manager, was most anxious to give information and every facility in his power to forward the great objects of the society; and Mr. Taylor, the engineer of the works, and by whom the chimney itself was designed, has made out a detailed description and drawing, showing minutely the dimensions and structure of every part of the work, and which he now requests Mr. B., along with his paper, to present to the society.

It was about the year 1848, owing to the extension of the works, that it became necessary to obtain increased chimney accommodation, both for increasing the draught of the furnaces and for carrying off the smoke and vapours from the works, and clear away from the neighbourhood by raising the chimney to a greater height. Three chimneys were then on the works, the highest of them rising 148 feet, and not exceeding 2½ feet square internally at the top. These gave vent to the smoke and vapours of 68 furnaces, heating 178 retorts, but were inadequate to work these effectually, and to give proper ventilation for cooling and purifying the retort houses for the comfort of the workmen, still less to meet the extensions of the works then contemplated and since executed. Instead of continuing, however, the system of small and low chimneys, and adding to their number, the plan came to be considered of raising one single chimney, sufficiently large and lofty to receive the flues from all the furnaces, and by one powerful column of heated air to work these, and any contemplated extensions, in a more effectual manner than hitherto, and so as to supersede the others and render any addition unnecessary for a long period. The idea had been acted on in some works already, and the magnificent chimney of St. Rollox chemical works furnished a favourable example. No way deterred, therefore, by the anticipated difficulties, or the great cost of the undertaking,* seeing especially that it promised beneficial results to the public, the directors determined to proceed with the plans made out at their request by Mr. Taylor. Having previously, however, requested Mr. Buchanan's opinion and advice thereon, he then carefully considered the whole subject, approved of the general design, and suggested only slight modifications in the form of the column and other points; but to Mr. Taylor still belonged the merit of the design, which he thought was great, as well as his talents and skill in superintending the work.

Mr. B. then proceeded to state from his reports some of the facts and principles regarding the work, which apply generally to all similar undertakings. And, first, in regard to the form of the structure, whether round or square; the square had been usually adopted in the works, but in the case of an altitude from 300 to 400 feet the round form was decidedly to be preferred, as presenting a less effective surface to the wind, whose violent action in this quarter it was important to diminish by every means. The effect of the wind on a cylindrical surface as compared with a square had been calculated by theory in the ratio of two to three. This is the Law of Resistance so beautifully demonstrated by the commentators on Newton's Principia. Subsequent experiments had proved the effect on the globe and cylinder to be, if anything, rather less than theory, so that we are quite safe in taking it at ⅔; the result is, that with 300 tons, for example, acting on a square tower, we have only 200 on the cylinder of the same diameter, which is most material. The bricks also, by being moulded to the circle, can be built and bound together with all the strength of the arch. On the lower part of the building, again, which is less exposed, and to be built of stone, the square and pedestal form are preferable.

Secondly. The building being intended to be 300 feet and upwards in height, the question arose how far the ordinary brick could withstand the pressure arising from so lofty a column. This difficulty was provided for by the increasing thickness of the walls of the chimney from the top towards the bottom, whereby the incumbent pressure being distributed over a larger and larger surface in descending, was diminished in proportion. The whole height from the foundation to the top is 341½ feet; of this 77½ feet are occupied by the foundation and square pedestal of stone, and 264 feet by the brick-work, the thickness of which was diminished towards the top by five successive steps. The upper division extended 83 feet down, and was 15 inches thick, and the internal diameter 11 ft. 4 in. at top; the 2nd division 58 feet and 20 inches thick; the 3rd, 48 feet and 25 inches; the 4th, 40 feet and 30 inches; and the 5th, 35 feet and 35 inches thick, and internal diameter 20 feet. On calculating the weight and pressure on each of those divisions, on the first it was found not to exceed 4½ tons on each square foot; in the middle it increased to 7 tons, and at the base it increased to 8 tons on each square foot. The strength of ordinary brick being estimated at from 20 to 30 tons, the work seemed within the limits of safety; but on finding that a composition brick could be obtained in the neighbourhood, from the brick works of Mr. Livingston, of Joppa, of much superior strength, Mr. Buchanan strongly recommended these, and also suggested experiments on their strength, of which he would give farther details on another evening, but found the first specimen tried bore at the rate of 440 tons to the square foot, a degree of strength almost incredible in such material. The results of the other experiments were somewhat similar, and all such as to set at rest any fears of the result. In regard to the sufficiency of the foundation itself, although this sustained the whole mass of the building, amounting to 4000 tons, yet the weight being spread over the entire area of the solid base, 40 feet square, it did not exceed 2½ tons to the square foot. And the material consisting of very hard till or blaes, of pretty equal solidity throughout, this appeared to form a good and sufficient foundation; and in order to be perfectly secure, the building at one of the angles was carried deeper than the rest, to obtain the same hard and solid bearing throughout. The result of these precautions, it is now very satisfactory to observe the structure standing perfectly upright and entire, without a crack or flaw of any description to be found in it.

The next object of importance that came to be considered was the effect of high winds on the building. From experiments, it was calculated that the force of a storm or tempest is equal to 12 lb. on the square foot of surface directly exposed; a great storm 18 lb., a hurricane 30 lb., and one capable of tearing up trees and oversetting buildings, 50 lb. There is no instance, however, of such a hurricane occurring in this country, and we are quite safe in assuming 40 lb. per foot, or 90 miles an hour, as the utmost power of the wind in this country. The French engineer, Fresnel, in an interesting memoir on the stability of the lighthouse of Belleisle and various other lighthouse structures compared with it, has assumed the force of the wind at 55 lb., agreeing with the estimate of another engineer, Navier; but this is evidently much beyond the truth, and the effect was to bring the gas-chimney in Paris below the zero of stability, although it stands as yet quite secure. Consider only the human body, which presents a surface from four to six feet square. Such a force of wind would be equal to a pressure of from 200 to 300 lb., and the power to overset at least equal to 500 lb., which no one could sustain for a moment, and even the ordinary inclosure-walls or chimneys would be immediately prostrated by it. Besides, it appears from observations of wind gauges, and particularly of one by Mr. Adie of this city, that the greatest force indicated on it for several years was only 14½ lb.; and another gauge, kept for several years at Granton Pier, and now at the Observatory, never indicated more than 18½ lb., and this was at Granton on the 9th and 27th of April, 1847. If we allow 40 lb., therefore, we are quite safe, this being nearly double what ever occurs.

Another point must be kept in view, that the tendency to overset the structure is greatly increased by the altitude, and this in fact exactly in proportion as the height exceeds the breadth of the base. It might happen also, if the strength of the different portions of the column were not duly proportioned, that it might be overset, not at the base, but at some intermediate point between it and the top. Applying these views, it was found that in the upper division, 83 feet down from the top, the force of the wind was 14½ tons, and this increased by the height and narrow base to 70 tons,

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* The whole cost of the work has been little short of 5000*l.* One of much less magnitude would have been sufficient for immediate wants—but after due consideration they thought it best to do the plan effectually at once.

while the actual weight was 270, giving a preponderance of stability of 3¾ to 1.

Taking the middle division, 189 feet from the top, the force of the wind was 37 tons, and this increased by altitude to 318 tons; but the weight of the structure being 880, there still remains a preponderance of stability of 2¾ to 1.

At the base of the column the force was 63 tons, increased by height to no less than 630, while the weight was 1670 tons, giving a preponderance of 2⅔ to 1, or rather less than the other points, and showing that the column could not overset but at the base.

At the base of the pedestal, again, the stability was fully greater, being 3½ to 1.

These results appeared very satisfactory, and the execution of the work has strikingly confirmed them. The stability and steadiness of the chimney, even in high winds, is remarkable; and while the old chimney, which is not half the altitude, is seen oscillating most sensibly by the naked eye, it is difficult to detect the smallest movement in the other by accurate telescopic observations with the theodolite. It is only in a violent gale, such as occurred on November 7th, that even a slight degree of oscillation could be distinctly observed. And when we consider how very usual it is for structures of this kind to oscillate in high winds (and even some of the lighthouses, which are of a more solid character, are not exempt from it), it is a strong proof of the strength of the work.

Drawings were then exhibited, and the comparative stability calculated of the small gas chimney, and of several other chimneys here and in France, all which were considerably below the present, and the French one pronounced by Fresnel as showing great hardihood—also the relative proportions and heights of some lighthouses; and lastly, a comparison was made, and drawings exhibited and described of the great chimney of St. Rollox, 455 feet in height, and consisting externally of a single cone tapering from the base to the summit, but not quite regularly, 41 feet in diameter at the base, and 13 at the top. The walls are in five divisions, increasing in thickness from top to bottom.

Another source of danger to be guarded against in these chimneys is the intense heat which often arises from the furnaces, and the powerful draught of the chimney. As a protection, an interior tube or chimney is generally built of brick standing clear of the outer chimney, and on which the effects of intense heat may be expended before it reaches the main exterior chimney. This is very effectual, but still the heat is great in issuing from the inner chimney, which should not be carried too high. In the present case, the inner chimney, 13 feet diameter, and lined with fire-brick, rises only 70 feet, and the walls of the chimney being then 35 inches thick, present great resistance; but as an additional precaution, he recommended near this part, hoops of iron, which have been carried at intervals of 35 feet all the way up within, and inclosed by the brickwork, so that they are not visible.

The only point remaining to be considered, and to which Mr. B.'s attention was particularly called, was the expediency of protecting the building by a lightning conductor. He had formerly, when the old chimney was erected, been consulted as to this, and considered it unnecessary, the height being moderate, and doubts being then entertained of the efficacy or expediency of such instruments. Much, however, has since been added to our knowledge and experience on this subject, and on the beneficial operation of conductors; so that he had no hesitation, the altitude also being so much greater, in recommending it. But having requested to be favoured with the views of a friend, and high authority, Professor Faraday, he gave an extract from his letter as follows:—"The conductor should be of ½-inch copper rod, and should rise above the top of the chimney by a quantity equal to the width of the chimney at the top. The lengths of rod should be well joined metallically to each other, and this is perhaps best done by screwing the ends into a copper socket. The connection at the bottom should be good; if there are any pump-pipes at hand going into a well they would be useful in that respect. As respects electrical conduction, no advantage is gained by expanding the rod horizontally into a strap or tube—surface does nothing, the solid section is the essential element.* There is no occasion of insulation (of the conductor) for this reason. A flash of lightning has an intensity that enables it to break through many hundred yards (perhaps miles) of air, and therefore an insulation of 6 inches or 1 foot in length could have no power in preventing its leap to the brickwork, supposing that the conductor were not able to carry it away. Again, six inches or one foot is so little that it is equivalent almost to nothing. A very feeble electricity could break through that barrier, and a flash that could not break through five or ten feet could do no harm to the chimney."

"A very great point is to have no insulated masses of metal. If, therefore, hoops are put round the chimney, each should be connected metallically with the conductor, otherwise a flash might strike a hoop at a corner on the opposite side to the conductor, and then on the other side on passing to the conductor, from the nearest part of the hoop there might be an explosion, and the chimney injured there or even broken through. Again, no rods or ties of metal should be wrought into the chimney parallel to its length, and, therefore, to the conductor, and then to be left unconnected with it."

In answer to some further inquiry, Professor Faraday again writes:—

"The rod may be close along the brick or stone, it makes no difference. There will be no need of rod on each side of the building, but let the cast-iron hoop and the others you speak of be connected with the rod, and it will be in those places at least, as if there were rods on every side of the chimney.

"A three-fourth rod is no doubt better than a half-inch, and, except for expense, I like it better. But a half-inch has never yet failed. A rod at Coutt's brewery has been put up 1¼ inch diameter; but they did not mind expense. The Nelson Column in London has a half-inch rod—three-fourths is better.

"I do not know of any case of harm from hoop-iron inclosed in the building, but if not in connection with the conductor I should not like it; even then it might cause harm if the lightning took the end furthest from the conductor."

The rod was constructed nearly according to these directions, of ⅝-inch copper, and the effect of it was very remarkably exemplified during the progress of the work. It was carried up regularly along with the building, and during storms, or a very electric state of the atmosphere, the electric fluid was distinctly perceived rushing down the rod, by a loud singing noise given out by it, arising from a tremor or vibration into which it was thrown, by a little play in the studs or eyes through which it passed in the building, and during these times the workmen were by no means fond of approaching too near it, but no harm ever occurred to any one from it.

The work of the chimney was commenced by laying the foundation on the 3rd of June, 1845, and during the course of that season the mason-work of the pedestal was completed, and the work allowed to stand til the spring. The brickwork of the shaft was commenced on the 2nd of May, 1846, and proceeded rapidly during the summer. The bricks and all the materials were taken up in the inside by means of a steam-engine working at the bottom, and winding a rope over a barrel, and this passing over a pulley on the top of the building, the materials were raised with the greatest facility; and it was curious to observe from different parts of the tower the work gradually rising, and the workmen steadily going on, at the great elevation to which they at last attained. A model was shown of a very simple apparatus, by which the stage for the materials and timbers was raised by successive lifts, as the building rose in height.

The contractors for the mason-work of the stone pedestal were Messrs. Gowan, and for the brick-work of the stalk Messrs. Bow, of Glasgow, to whom much credit is due for the superior style in which they have finished their work; and it may also be mentioned, that no accident or casualty of any serious nature occurred during the execution of this great work.

Several observations still remained to be made on Part II. as to the draught of the chimney, but were deferred to another day, as well as Mr. Taylor's paper, to give time for the distribution of the prizes for last session.

Thanks voted to Mr. Buchanan.

NOTES OF THE MONTH.

Sir John Rennie and Mr. Brunel, at the request of the parish authorities, have made their report on the failure of Warren's Girder Bridge, over Joiner-street, London-bridge (*ante* p. 390), which contains their joint and decided opinion,—that the bridge, as constructed, was insufficient, and ought not to be replaced by one of similar construction.—Mr. Barlow, the engineer of the railway, has addressed a letter to the *Times*, stating that he entirely disagrees with the above report; and that he does not consider the principle of the bridge either incorrect or objectionable. We advise Mr. Barlow not to kick over the traces; he had better keep quiet and make the best of a bad business. We are very anxious to hear the result of the testing of the bridge; we left our card with Mr. Barlow's assistant at the time the experiment was being made, and begged that he would favour us with the amount of deflection for every 10 tons' dead weight laid over two of the girders, and the final result of the experiment. Although the testing took place three weeks since, we have not been favoured with any particulars. If Mr. Barlow wishes to stand well in his profession, we advise him not to conceal any similar information: he may rely upon it that a fair statement does more good than any concealment.

Portugal boasts of her first steam-engine. A tug, with engines from an English factory at Oporto, has towed a ship over the bar of the Douro. The Portuguese speak of being independent of foreign aid in constructing engines. Save the mark!

The third number of Mr. Tinkler's 'Architectural Sketches in Italy' is partly occupied with villa subjects, which will naturally be of interest to his readers. Some of these villas are suited only to the Roman climate and habits of life; but their picturesque arrangements will afford some ideas for study here, and they will therefore be the more valuable, as they are suggestive without admitting of direct copying. Some of the gateways, sketched under the name of Fragments at Rome, are likewise of considerable interest.

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* The very reverse of what was formerly held by high authorities.

The *United Service Gazette* makes the following remarks on the construction of an efficient new dock at Devonport:—"On the 21st the whole Board of Admiralty, with the principal Secretary, assembled at Somerset House, and sat for many hours in deliberation on the subject. The Devonport Master Shipwright was in attendance with *his* plans, and Colonel Green, the C.E. and Architect of the Board, was also present to support the plans which have been condemned by Mr. Edye, and are now being carried out at an enormous expense. The world will laugh at the idea of these men setting up themselves to correct such celebrated civil engineers as Walker, Rendel, and Cubitt—names rendered historical by their great works, and will not fail to remember the Shakesperian adage, 'Fools rush in where angels fear to tread.' The first stone of the new basin dock, according to the Admiralty plan, was laid on the 20th, without form or ceremony of any kind. It was characteristic of the abortive plan; and with so untimely a birth, we cannot help prophecying that this Somerset House infant will never live to be reared."—Our contemporary continues: "We notice with great regret the report that the caissons at the new and spoiled steam basin and dock works at Keyham have failed, although so much was said of their admirable perfection and utility when tried the other day, and of the *inventor*, Mr. Scamp, Assistant Director of Engineering Works at the Admiralty. The whole design looks very much like a gigantic blunder, at the expense of some 20,000*l.*; and now it is said the Admiralty department are endeavouring to make Mr. Fairbairn, the contractor for building the caissons, responsible for the design as well as for the faithful construction of them. Thus, if the caissons had succeeded, the wiseacres of Somerset House would have assumed all the credit; but now that they are likely to fail, or have not succeeded, the contractor is saddled with the onus of the mistake."

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM NOVEMBER 2, TO NOVEMBER 21, 1850.

Six Months allowed for Enrolment unless otherwise expressed.

Matthew Hodgkinson, of Red-street, near Newcastle-under-Lyne, Stafford, mine agent, for improvements in furnaces or apparatus for smelting ores and minerals, and for the making of pig iron.—November 2.

Victor Emile Warmont, of Neuilly, Seine, France, for improvements in dyeing wool and other fibrous materials and fabrics.—November 2.

Joseph Christian Davidson, of Yalding, Kent, brick maker, for improvements in lime and other kilns and furnaces.—November 2.

John Matthews, of Kidderminster, foreman, for improvements in sizing paper.—November 2.

Jonas Bateman, of Upper-street, Islington, cooper, for improvements in life-boats.—November 2.

Archibald Slate, of Woodside Iron Works, Dudley, for improvements in canal navigation.—November 2.

Pierre Antoine Auguste de la Barre de Nanteuil, of Leicester-street, Middlesex, for improvements in propelling carriages. (A communication.)—November 2.

William and Colin Mather, of Salford, engineers, and Ferdinand Haselowsky, of Berlin, Prussia, engineer, for improvements in machinery, for washing, steaming, drying, and finishing cotton, linen, and woollen fabrics.—November 2.

John Borland, of Norfolk-street, Strand, engineer, for certain improvements in weaving machinery.—November 2.

John Slate, of Wandsworth, Surrey, accountant, for improvements in stoves and furnaces, and in chimney-pots and regulators.—November 2.

John Tatham and David Cheetham, of Rochdale, Lancaster, machine-makers, for certain improvements in the manufacture of cotton and other fibrous materials and fabrics composed of such materials.—November 2.

Richard Clyburn, engineer to the firm of D. Maclean and Son, of St. George-street East, Middlesex, for improvements in wheel carriages. (A communication.)—November 2.

James Black, of Edinburgh, machine-maker, for a machine for folding. (A communication.)—November 7.

Richard Archibald Brooman, of the firm of J. C. Robertson and Co., of Fleet-street, patent agents, for improvements in railways. (A communication.)—November 7.

William Fairbairn, of Manchester, Lancaster, civil engineer, for improvements in cranes and other lifting or hoisting machines.—November 7.

William Crane Wilkins, of Long-acre, Middlesex, engineer, for an invention for lighting, and in apparatus for lighthouses, signal, floating, and harbour lights.—November 7.

Samuel Edwards, James Ansell, and Patrick Heyns, of Shadwell, Middlesex, engineers, for certain improvements in obtaining and applying motive power, and in pumps.—November 7.

George Frederick Morrell, of Fleet-street, London, gentleman, for improvements in obtaining and applying motive power, and also in pumps.—November 7.

John Alexander Lerew, of Boston, America, gentleman, for certain improvements in sewing machines.—November 7.

Benjamin Guy Babington, of George-street, Hanover-square, Middlesex, Doctor of Medicine, for improvements in preventing incrustation of steam and other boilers.—November 7.

Robert Clare, jun., of Exchange-buildings, Liverpool, gentleman, for improvements in the manufacture of metallic casks.—November 7.

John Robinson, of Stepney, Middlesex, engineer, for improvements in lifting and moving fluids and other bodies, and in apparatus for steering ships and other vessels.—November 7.

David Christie, of St. John's-place, Broughton, Salford, Lancaster, merchant, for improvements in machinery or apparatus for preparing, carding, spinning, doubling, twisting, weaving, and knitting cotton, wool, and other fibrous substances, also for sewing and packing. (A communication.)—November 7.

Robert Lucas, of Furnival's-inn, London, mechanical draughtsman, for improvements in telegraphic and printing apparatus. (A communication.)—November 7.

Thomas Main, of the Strand, printer, for improvements in printing machinery.—November 8.

James Rock, jun., of Hastings, Sussex, coach-builder, for certain improvements in carriages, which are also applicable, in whole or in part, to other machinery.—November 9.

William Palmer, of Sutton-street, Clerkenwell, manufacturer, for improvements in the manufacture of candles and night lights.—November 9.

James Scott, of Falkirk, N. B., shipwright, for certain improvements in docks, slips, and apparatus connected therewith.—November 9.

Sir Francis Charles Knowles, of Lovell, Bucks, Bart., for improvements in the manufacture of charcoal.—November 9.

Lucien Vidie, of 14, Rue du Grand Chantier, Paris, France, French advocate, for improvements in measuring the pressure of air, steam, gas, and liquids.—November 9.

Joseph Nye, of Mill Pond Wharf, Old Kent-road, engineer, for improvements in hydraulic machinery, parts of which improvements are applicable to steam-engines and machinery for driving piles.—November 12.

George Robins Booth, of London, engineer, for improvements in the manufacture of gas.—November 12.

Peter Spence, of Pendleton, Manchester, manufacturing chemist, for improvements in the manufacture of alum and certain alkaline salts, and in the manufacture of cement, part of which improvements are applicable in obtaining volatile liquids.—November 12.

Edwin Clark, of Palace New-road, Middlesex, civil engineer, and Henry Mapple, of Child's Hill, Hampstead, for improvements in electric telegraphs, and in apparatus connected therewith.—November 12.

Henry Medhurst, engineer, in the employ of Messrs. Shears and Sons, of Bankside, Southwark, for improvements in gas meters.—November 12.

Etienne Masson, of Place St. Michael, Paris, gardener, for improvements in the preparation of certain vegetable alimentary substances for the provisioning of ships and armies, and other purposes where the said substances are required to be preserved.—November 12.

John Ball, of Ashford, Kent, engineer, for improvements in applying heat to bakers' ovens and their appendages.—November 12.

Henry Wimshurst, of Limehouse, Middlesex, shipbuilder, for improvements in steam-engines, in propelling, and in the construction of ships and vessels.—November 12.

Charles Marsden, of Kingsland-road, Middlesex, engineer, for improvements in scissors and thimbles.—November 12.

William Duckworth, of Liverpool, coffee merchant, for certain improvements in the manufacture of chicory, with certain improvements in the machinery or apparatus for the manufacture thereof.—November 14.

Thomas Shore, of Exwich, Devon, miller, for an improved method of dressing flour. November 14.

Robert Howarth, of 61, Chapman-street, Oldham-road, Manchester, for improvements in machinery for raising a nap on cotton, woollen, silk, and other fabrics.—November 14

Abraham Haley, of Frome, Somerset, machinist, for certain improvements in looms for weaving.—November 14.

Edward David Ashe, of Brompton, Middlesex, Lieutenant in her Majesty's navy, for a new or improved nautical instrument or instruments applicable especially amongst other purposes to those of great circle sailing.—November 14.

John Swindells, of the firm of Swindells and Williams, of Manchester, and Juce, near Wigan, manufacturing chemist, for certain improvements in obtaining products from ores and other matters containing metals, and in the preparation and application of several such products, for the purpose of bleaching, printing, dyeing, and colour making. —November 14.

Joseph Conrad Baron Liebhaber, of Paris, France, for improvements in blasting rocks; also in working marble and stone, and in preparing products therefrom.—November 14.

Charles Allemand, of Paris, France, gentleman, for an improved apparatus for producing light.—November 14.

Thomas Coats, of Ferguslie, Paisley, Renfrew, Scotland, thread manufacturer, for certain improvements in turning, cutting, and shaping wood and other materials.—November 16.

Joseph Martin, of Liverpool, Lancaster, rice miller, for improvements in machinery and apparatus for cleansing and otherwise treating rice and other grains, seeds, and farinaceous substances.—November 16.

Thomas Allan, of St. Andrew's-square, Edinburgh, printer and publisher of the *Caledonian Mercury*, for certain improvements in electric telegraphs, and in the application of electric currents for deflecting magnets and producing electro-magnets.—November 16.

William Laird, of Liverpool, Lancaster, merchant, and Edward Alfred Cowper, of Handsworth, Warwick, engineer, for improvements in machinery for loading and discharging certain descriptions of cargo in ships and other vessels, and in the construction of such vessels.—November 16.

John Hosking, of Islington, Middlesex, engineer, for certain improvements in valves applicable to pumps, and also in apparatus to regulate the pressure and flow of water and air through pipes.—November 19.

Thomas Duron, of Windsor Bridge Iron Works, Pendleton, near Manchester, Lancaster, engineer, for improvements in machinery and apparatus for moving engines from one line of rails to another, and for turning them; also for compressing certain substances, and for raising and lowering heavy bodies.—November 19.

Paul de Tolstoy, of Paris, France, General in the service of his Majesty the Emperor of Russia, for improvements in dredging machines. (A communication.)—November 19.

Clement Augustus Kurtz, of Manchester, Lancaster, practical chemist, for improvements in dyeing. (A communication.)—November 19.

Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for an improved composition applicable to the coating of wood, metals, plaster, and other substances which are required to be preserved from decay, which composition may be also employed as a pigment or paint. (A communication.)—November 19.

Robert Brown, of Liverpool, Lancaster, plumber and brass-founder, for improvements in the application of pumps for raising and forcing water.—November 19.

Henry William Ripley, of Bradford, York, dyer, for improvements in dressing and finishing piece goods.—November 19.

John James Greenough, of the Strand, Middlesex, gentleman, for improvements in the construction of chairs, couches, and seats, parts of which improvements are also applicable to various purposes where springs for supporting heavy bodies and resisting sudden and continuous pressure are required. (A communication.)—November 21.

ERRATA.—In the article on "Motion of Water in Pipes," p. 374, col. 2, line 58, *for* "R and I," *read* "A and I;" line 67, *for* "of," *read* "at;" line 68, *for* "increasing," *read* "indicating."

Page 375, and throughout the paper, *for* "x," *read* "a;" col. 2, line 35, and 42, *for* "formulæ," *read* "formula."

Page 376, col. 1, line 19, *for* "Changes," *read* "Change;" line 38, *for* "Yénleys," *read* "Génieys;" line 64, *for* "bend," *read* "head.—Col. 2, line 19, *for* "bend," *read* "head;" line 24, *for* "aperture at the end," *read* "aperture of discharge;" line 32 and 50, *for* "S^2_n," *read* "s^2_n."

END OF VOLUME XIII.