HARTFORD STEAM BOILER ★ INSPECTION AND INSURANCE CO. ★

HARTFORD, CONN.

The Locomotive.

PUBLISHED BY THE

HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.
HARTFORD, CONN.

NEW SERIES.
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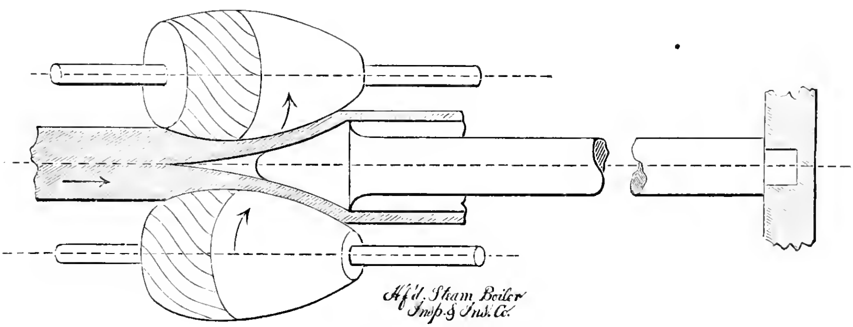
NEW SERIES—VOL. XII. HARTFORD, CONN., JANUARY, 1891. No. 1.

Rolling Seamless Tubes.

In the December number of the LOCOMOTIVE we gave an account of the Mannesmann process of rolling tubes from solid bars. Considerable interest in this subject has been felt by the engineering world ever since the process was first proposed. We have been requested to publish a fuller account of the action of the rolls than we gave in the December LOCOMOTIVE, and we accordingly give the following article, which is substantially the same as an address delivered by Mr. Frederic Siemens, C. E., before Section G of the British Association some time ago. It may be well to say that we have not seen the process in operation ourselves, so that we cannot give as satisfactory a description of it as we would like to.

Most engineers will have heard of the tube-rolling process of Messrs. Mannesmann, whose modest title barely indicates its great importance. Tubes occupy an important



ROLLING SEAMLESS TUBES.

place in the wants of mankind, for in addition to their use as tubes, properly so called, they possess, also, the most advantageous form for columns, rods, axles, bearers, struts, etc. A given quantity of material can be formed into no other shape so strong as the tubular. Mr. Siemens took an interest in the invention, because he was desirous of increasing the use of open hearth steel, which, as well as copper, is particularly adapted to the process, wrought iron being comparatively unsuitable.

Hitherto steel tubes could only be made with difficulty and at high cost by a complicated process, and even then they had imperfectly welded seams and a longitudinal fiber. Now from a rough ingot of cheap steel, with one, or, at most, two operations, a perfect tube without seam and with a circular fiber is produced. It may be seen from this bare statement how great is the importance of the invention. If it is considered that by the process in question tubes of great length and diameter, and of almost any desired thickness of metal, can be produced at a comparatively low cost, air-tight, and possessing three or four times the resisting power of the best welded tubes of wrought iron, it can hardly be doubted that a great future is opened out for their use in technical arts and industries, in architecture, and in the manufacture of implements of warfare.

At present, when we roll a bar of iron, we pass it endwise between a pair of rolls turning in opposite directions. Grooves are cut around the rolls of the sectional form desired in the finished bar, and the bar is forced into these grooves. The rolls do not make the bar revolve. They act simply on its surface, drawing the material forward and forcing it into the prepared grooves at the same time that they lengthen it and reduce its sectional area. The fiber produced in the finished product is, of course, longitudinal.

Another way of rolling is known, and is used for straightening and polishing bars. Two or three rolls, running parallel to each other, or nearly so, are used, and the bar is introduced in the direction of their axes instead of perpendicularly thereto. In such rolls the bar is not drawn forward, but simply rotates. It is elongated if sufficient pressure is used, but no decided fiber is produced.

The Mannesmann process occupies a sort of intermediate position between the two. Two (or three) rolls are used, as shown in the cut, but they do not lie parallel to one another. Their axes form acute angles with one another, and with the bar lying between them. When thus set, the rolls act on the bar to draw it forward, as well as to make it revolve, or, in other words, they impart to it a spiral movement. Though constructively both systems of mills may appear much the same, they differ widely in their mode of working and in their results. This arises from the position which the article acted upon, and which we will continue to call a bar, is made to take up, and the very different action and form of the rolls. In the Mannesmann machine a certain relation is maintained between the forward movement of the bar and its rotating movement, and if the proportion between longitudinal and rotary motion is properly adjusted to the special material acted on, the displacement in the substance of the bar is regulated so that a systematic twist is given to the fiber by which not only irregular breakage of the material is avoided, but an energetic working action is secured, causing the great strength and toughness the tubes produced by this process are proved to possess.

The old straightening and polishing machine, although outwardly similar to the Mannesmann tube-rolling machine, owing to the form and position of the rolls and bar, admits of no twisting and displacement of material, and consequently this machine confines itself to surface action, as, indeed, it professes to do by its title.

The following remarks may assist in clearing up this singular difference, and explain the peculiar action of the Mannesmann rolls, which, while acting on the outer surface of a solid bar, produce a regular hollow space inside the same, — in short, a tube. To obtain a simple forward spiral action of the bar, the length of the rolls is immaterial; it will take place when the rolls are reduced to the form of thin disks. Supposing the disks to be infinitely thin, or, what is the same thing, that their outer edges are reduced to a mathematical line, and no sliding motion takes place, the bar must still move forward spirally, its spiral velocity being equal to the velocity of the outer circumference of the disks. If, instead of one pair of such thin disks, several pairs of disks of regularly increasing diameters are made to revolve on the same axis, the outer circumference of each disk will revolve with greater velocity than that of the preceding one. The same bar is, however, drawn forward through the several pairs of disks, and thus, as each part of the bar enters successively a more advanced pair of disks, the velocity with which that portion of the bar rotates increases, and it is drawn forward by each succeeding pair of disks, as they catch hold of it, with ever increasing speed.

It will be understood that when a bar passes through such a series of disks, no slipping being possible, the material of which it is composed cannot retain its original area or volume. The diameter of the bar being regulated by the disks, while simultaneously a violent stretching action is carried on, the material required can only be drawn from the inside of the bar, and thus a hollow space is formed.

Instead of this peculiar arrangement of disks a conical, or rather conoidal, pair of rolls, which amount to the same thing as the disks, considered as joined together, may be provided. It follows that a bar or rod of suitable dimensions which is passed through the Mannesmann rolls will, provided its substance is sufficiently homogeneous and plastic, undergo a violent twisting and stretching action, the fiber being spun as is the fiber in a rope, on account of which the process may appropriately be called a torsional one. The bar in its passage through the rolls is twisted as thread is twisted in a spinning machine. As, however, it cannot be fed from the outside as is the thread, and as has been said, the diameter cannot be reduced on account of the action of the rolls, it is forced to draw on the interior for a supply of material. Let us attempt to explain in another way.

The tube is made thus: A bar is placed between the conoidal rolls at the part where their diameter being least, the speed at which they move to make a revolution is also least. The rolls seize the bar and draw it into contact with parts of the cones which move more and more rapidly, though, owing to the way in which the rolls are set, the space left between them for the passage of the bar decreases slightly. Slight, however, as is this decrease in the space between the rolls, a certain amount of material has to be shifted. The action of the rolls prevents this material from being taken from the outside of the bar, and consequently it is drawn from the interior — hence the hollow, hence the tube. Soon after entering the rolls, a small central fracture is formed which widens out to a hollow space as the increased stretch is made to take effect in an increased twist acted on from the surface.

The increasing twist of the fiber of the bar while passing through the rolls and the peculiar relation kept up between longitudinal and turning action is the characteristic of the Mannesmann tube-rolling machine, and it is this action that enables it to make a tube from a solid bar or ingot.

Though the bar is thus converted into a tube by the action of the rolls, and their action only, a mandrel is generally used to finish and smooth the interior and enlarge the tube. This use of the mandrel has led to the erroneous belief that it is essential to the formation of the hole. No machine, however, could stand the strain if it were attempted to force a mandrel longitudinally through a solid bar of hot steel. Such an operation is impossible. Just sufficient power is used to form the hollow in the bar from the action of the rolls on the outside, and into this hollow the mandrel enters, smoothing the inside, and, when required, enlarging the tube. Thus we have the strange experience in rolling that by one operation the bar is made hollow and also longer and wider than when it entered the rolls a few seconds before.

In a specimen exhibited by Mr. Siemens there was proof that the hollow in the interior of the bar is formed without the intervention of a mandrel. The piece referred to was obtained by interrupting the action of the rolls while the bar was still on its way through them, and then breaking off the bar so as to expose that part where the hollow is just commencing to form. The piece was sound in its solid part as well as in the hollow part, and the inner surface of the commencing tube was crystalline. This shows that no mandrel could have acted on it. Besides this, the inner surface was not oxidized as it would have been if it had been exposed to the air at a red or white heat. The bright surface was preserved because no air could enter the tube during its formation. Until such a specimen is cut open, a vacuum exists in the interior, both ends being hermetically closed. Such a specimen is made by slightly pointing the bar at the two ends, so that they escape the full action of the rolls at the entry and exit.

This curious result can always be obtained, and it quite disposes of the allegation that the hole is made by a mandrel. The specimen showed also both how the tube in the center commences by a fracture of the metal and widens out, and also the twist of the fiber, which had the appearance of a rope. This peculiar twist of the fiber assists in giving the tubes their great toughness and resisting power. The various specimens exhibited by Mr. Siemens were mostly produced from the relatively cheap open hearth steel. The Mannesmann process in shaping metals upsets most of the hitherto accepted ideas and conditions, inasmuch as, instead of avoiding any twist of the fibers, it by one operation gives the greatest possible twist to the fiber with a corresponding stretch of material. Moreover, as has been said, it may, assisted by a mandrel, increase the outer diameter of a bar instead of diminishing it, as do all other rolling mills. The tube produced by the Mannesmann process is generally greater in diameter than the bar from which it is formed. The child is at its birth larger than the parent.

From the description and facts here attempted to be given, it is evident that we have in the Mannesmann process a system of rolling as new as it is capable of producing effects hitherto not contemplated. In combining all the various systems of rolling as described above, it may claim to be called the universal system of rolling, in which all hitherto known rolling processes represent a part. The old polishing and straightening machine could never, it is evident, produce like results, because the essential constructive conditions are wanting. "It is remarkable," said Mr. Siemens, "that competitors and otherwise competent men rejected the Mannesmann process as either not new or as being wrong in principle and generally impracticable, and this sweeping condemnation was supported by arguments apparently logical and sound. I trust this short explanation of an intricate and novel process, and I may say principle, of rolling tubes from solid ingots may assist in dispelling the incredulity and prejudice that has grown up around it. In face of the numerous possible applications of the process, great difficulties may yet have to be mastered, but it may be safely foretold that these will mostly be overcome on account of the true principle on which the process is based and by the energy and intelligence that have conducted it to its present advanced state."

Inspectors' Reports.

SEPTEMBER, 1890.

During this month our inspectors made 5,379 inspection trips, visited 9,592 boilers, inspected 4,264 both internally and externally, and subjected 667 to hydrostatic pressure. The whole number of defects reported reached 9,272, of which 694 were considered dangerous; 39 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	577	36
Cases of incrustation and scale,	922	23
Cases of internal grooving,	57	1
Cases of internal corrosion,	292	11
Cases of external corrosion,	572	30
Broken and loose braces and stays,	78	23
Settings defective,	262	24

Nature of Defects.	Whole Number.	Dangerous.
Furnaces out of shape,	347	15
Fractured plates,	147	54
Burned plates,	155	16
Blistered plates,	259	6
Cases of defective riveting,	2,421	148
Defective heads,	74	13
Serious leakage around tube ends,	1,927	132
Serious leakage at seams,	307	14
Defective water-gauges,	267	33
Defective blow-offs,	83	23
Cases of deficiency of water,	26	9
Safety-valves overloaded,	45	10
Safety-valves defective in construction,	50	19
Pressure-gauges defective,	314	29
Boilers without pressure-gauges,	16	16
Unclassified defects,	74	9
Total,	9,272	694

October, 1890.

During this month our inspectors made 5,722 inspection trips, visited 10,954 boilers, inspected 4,041 both internally and externally, and subjected 699 to hydrostatic pressure. The whole number of defects reported reached 9,581, of which 894 were considered dangerous; 19 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	652	31
Cases of incrustation and scale,	1,006	32
Cases of internal grooving,	35	2
Cases of internal corrosion,	293	17
Cases of external corrosion,	669	43
Broken and loose braces and stays,	92	32
Settings defective,	229	25
Furnaces out of shape,	346	6
Fractured plates,	238	66
Burned plates,	152	14
Blistered plates,	266	16
Cases of defective riveting,	2,264	42
Defective heads,	49	6
Serious leakage around tube ends,	2,192	432
Serious leakage at seams,	289	29
Defective water-gauges,	259	25
Defective blow-offs,	75	15
Cases of deficiency of water,	13	4
Safety-valves overloaded,	38	7
Safety-valves defective in construction,	58	29
Pressure gauges defective,	274	13
Boilers without pressure gauges,	5	5
Unclassified defects,	87	3
Total,	9,581	894

Boiler Explosions.

NOVEMBER, 1890.

KITCHEN BOILER (176). Shortly after 10 o'clock on the morning of Nov. 1st, a terrific explosion, accompanied by a crash of glass, was heard at the residence of George A. Baker, 904 North Seventeenth Street, Philadelphia. The noise came from the kitchen, and when it subsided the members of the family who were home at the time rushed there and found that almost every article in the room was demolished. It was found that the boiler of the range had exploded. Fortunately there was no one in the kitchen at the time. The damage done by the explosion will reach $200.

SAW-MILL (177). J. B. Lambert's saw-mill boiler, near Johnstown, Pa., exploded on Nov. 5th. His mill is located on Murdock's steel tramway, two miles from Mostoller Station, on the Somerset & Cambria Railroad, and has been cutting for Murdock all summer. Mr. M. Trent, one of the haulers, was seriously injured, though his recovery is expected. Fortunately none of the other men were injured, except the sawyer, who was badly bruised. The fireman states he had only eighty-five pounds of steam on, and had just finished filling the boiler with water about five minutes previous to the explosion. Large pieces of the boiler are scattered through the woods within a radius of a quarter of a mile. The engine has not been found—not even a piece of it—thus far. Everything about the building, boiler, and engine was a total loss.

COTTON-GIN (178). The boiler of J. W. Baker & Co's gin, at Dyersburg, Tenn., exploded on Nov. 7th, completely wrecking the gin building, also the adjoining building of the Dyersburg Machine Works, and instantly killing two men, the engineer and fireman. All the glass in the windows for some blocks around were broken, and the boiler, weighing two tons, was thrown half a mile across town and struck Levi Green's gin, almost wrecking it. Loss, $5,000.

GINNERY (179). At 12 o'clock on Nov. 7th, the engine of the Alliance ginnery, in the heart of the town of Thomaston, Ga., exploded, killing Len Rogers, colored, the engineer, scalding Calvin White, colored, wounding Sam and Tom Weaver, colored, and also J. C. Thompson, manager, and W. G. H. Ferguson. There is no sign that an engine was ever at the place. The debris flew in every direction. The walls of the residences of Mr. Alexander and Mr. T. B. Bethel were shattered and a brick entered the wall of the Cheney House, 100 yards away. The shock was terrible, and it is now impossible to tell the damage.

WAREHOUSE (180). The boiler and engine used to operate the Farmers' warehouse, at Brookings, Ia., was completely destroyed on Nov. 7th, together with the engine building, by the explosion of the boilers. The warehouse proper is uninjured. No lives were lost. The fire alarm was given, but no work on the part of the fire department was needed. No cause can be assigned for the explosion unless it be the employment of inexperienced help to run the engine.

SAW-MILL (181). The boiler at the saw-mill of M. J. Wright & Son, near Magnolia, Miss., exploded on Nov. 8th, killing two men, Sam Pritchard and Nelson Andrews, fatally injuring two others, and seriously injuring two more.

THRESHER (182). On Nov. 13th the boiler of a threshing machine exploded in Russia Township, Polk County, Minn. Mr. W. D. Tomlin, of Duluth, inspector of boilers for that district, states that the boiler was run at too high a pressure. We have been unable to find the list of killed and injured.

STOVE FACTORY (183). A terrible accident took place at Mertztown, Pa., on Nov. 17th, which resulted in the death of three men and serious injuries to seven others. While the employes of Edward Trexler's stove factory were preparing to start work for the day and the engineer was getting up steam in the boilers, one of the large boilers exploded. The building was completely wrecked. Henry Epler, Sassaman Hilbert, and Charles Oswald were instantly killed. Among the more seriously injured are Samuel Epler, Frederick Delong, Albert Reppart, James Bausher, and Charles Albert. All were terribly scalded, and Epler, Delong, and Albert also had limbs broken. The exact cause of the explosion is not known. The force of the concussion was felt a distance of five miles. Charles Bauscher was badly cut and Charles Wolbert received fatal injuries. All seven of the injured men were standing in the boiler-house warming themselves when the explosion occurred.

PORTABLE BOILER (184). A portable boiler at the Marblehead pumping station, Marblehead, Mass., exploded on Nov. 19th. John Dunn, the engineer, was killed. T. B. Robertson, superintendent of the works, was fatally injured about the head, back, and legs, and Timothy Shaughnessey had a leg broken. Edward McKenna was cut about the face and Antonio Achusen received slight abrasions. From the ante-mortem statement of Mr. Robertson, the foreman, who died on the following Thursday, it appears that the hoisting engine fed by the boiler was not running a few moments before the explosion. They had been adjusting a crank pin. Robertson told Dunn that they were ready to start up, and Dunn went into the engine-room presumably for that purpose. Contractor Shaw said that he purchased the boiler about two years ago from a Mr. Houghton in Boston. He though it was a safe one in all respects. At last accounts Ed. McKenna and T. Shaughnessy, the two injured men at the hospital, were doing well.

SAW-MILL (185). The boiler in the saw-mill of Shaw Bros., located near Lima, O., exploded with frightful force on Nov. 24th, throwing pieces 150 yards. Several of the employes were severely, but not dangerously, injured. The mill is a total wreck. The financial loss is estimated as about $1,200.

SAW-MILL AND COTTON-GIN (186). The boiler of John Cline's saw-mill and cotton-gin at Toolca, eighteen miles from Shelby, N. C., exploded on Nov. 24th, demolishing the machinery and instantly killing Gus Cline, a sixteen-year-old son of the owner. John Chapman was so badly injured that he died in a short time. John Buff's eyes were destroyed and he cannot recover. John Hoyle, another employe, is dangerously injured, his thigh being badly fractured.

SAW-MILL (187). The boilers of Jewitt's steam saw-mill of South Bay, on the Canadian Pacific Railway, five miles from St. John, N. B., exploded on Nov. 25th, tearing the boiler-house into fragments and instantly killing five workmen and wounding eleven others, two or three fatally. There were six boilers in the mill. The engineer was at breakfast when the explosion took place, and no one can account for the accident. Sixty men were at work at the time, and ten minutes before the explosion twenty were on top of the boiler-house. The main boiler, thirty feet long, was hurled three hundred yards in a northerly direction into the river, and another boiler about one hundred yards in the opposite direction, tearing a ditch several feet deep through a solid earth embankment of railway track, clear of the scattered debris and out over the tops of deal piles. Michael Lynch's dead body was found on the top of the main mill building. Lynch had only gone to work that morning. By his side lay five others severely wounded. How they were hurled there is as much of a mystery as the origin of the explosion. Others were buried deep beneath the debris of the boiler-room and were rescued with difficulty. The death of the little deaf and dumb boy, Bert Currie, was perhaps the saddest of the fatalities. The little fellow's father worked in the mill, and he had been playing around him and had been sent away many times, but always came back. Not five minutes before the explosion his father ordered him home, and the lad was returning again when he was killed by one of the falling timbers.

SAW-MILL (188). The boiler of John A. Ackers & Co.'s steam saw-mill at Scotland, Worth County, Ga., exploded on Nov. 27th, killing three men and injuring four others. The killed are Augustus Stinson, Thomas Sammons, and Adolphus McMillan. The wounded are John H. McPhail, Andrew Cox, William Tompkins, and James Daniels (colored). The boiler was blown a distance of seventy-five yards. The cause of the explosion is unknown.

On Zinc in Boilers and Heaters.

It has sometimes been noticed that zinc, when used in a boiler to prevent corrosion, gives rise to a peculiar action on the iron of the boiler or heater. We have seen iron modified in this manner to such an extent that it could easily be cut with a knife, though it would harden up again if laid away by itself. While not pretending to explain this curious behavior, we would like to suggest that commercial zinc is never pure, and that lead enters into it, sometimes in considerable proportions. If a pig of zinc, containing an appreciable proportion of lead, were introduced into a boiler or heater, we should expect it to work all right until the zinc became entirely, or almost entirely, oxidized: but after that, the electrical relations of the pig and the heater might be reversed, the metallic lead in the pig becoming the positive element, and the iron of the heater the negative element. This would cause the electric current to pass through the water from the iron to the lead, and if this current were strong enough to decompose water, the hydrogen would be set free upon the surface of the lead, and the oxygen upon the surface of the heater. Electrolytic oxygen is particularly active, and will attack metals very readily. It might happen, therefore, that a pig of impure zinc would become a very undesirable thing to have in a boiler after the zinc had become pretty well oxidized.

We do not present the foregoing as an *explanation* of the peculiar action sometimes observed, for we are not prepared to substantiate it. We merely wish to call attention to the possibility of such an action, and to suggest that it may be worth while to investigate the effect of the presence of lead in a zinc pig. It may be that the electromotive force of a lead-iron-water battery is not sufficiently great to decompose water. In that case it seems that the action suggested above would not be possible. At all events, it is a good plan to use as pure a quality of zinc as can be obtained readily, and to renew it before it is all used up.

MR. H. W. SPANGLER, professor of mechanical engineering in the University of Pennsylvania, has written a most excellent little treatise on *Valve Gears*, a copy of which Messrs. John Wiley & Sons have forwarded to us. Mr. Spangler employs the Zenner diagram in his analyses of the motions of the valves. The designing of valve gears, as he says in the preface, is entirely a drawing board process; and in all but radial gears, and to a great extent even there, he has given the actual method of laying down the work. It may also be noted that the problems he gives are mostly taken from engines actually in use. He has considered almost every kind of valve gear that is in use, and the book, though primarily designed as a text book, cannot fail to be useful to all engineers.

Graves of Great Men.

Of those who have adorned the literature of our language, Chaucer, Spencer, Beamont, Drayton, Cowley, Denham, Dryden, Addison, Prior, Congreve, Guy, Johnson, Sheriden, and Campbell lie in Westminster Abbey. Milton was buried in the churchyard of St. Giles, Cripplegate; Pope, in the church at Twickenham; Swift, in St. Patrick's, Dublin; Thompson, in the churchyard at Richmond, in Surrey; Gray, in the churchyard at Stoke-Pogis, the scene of the "Elegy;" Goldsmith, in the churchyard of the Temple church; Cowper, in the church at Dereham; Burns, in St. Michael's churchyard, Dumfries; Byron, in the church of Hucknall, near Newstead Abbey; Coleridge, in the church at Highgate; Sir Walter Scott, in Dryburgh Abbey; Southley, in Crosthwaite church, near Keewick.

In this country there is no one national cemetery of pre-eminence. Webster is buried in "an ancient burying-ground," overlooking the sea, near Marshfield, where he lived; and, in like manner, Clay's grave is near his home at "Ashland," in the cemetery at Lexington. Bayard Taylor lies at Longwood, a little cemetery within sight of his birthplace at Kennet. Seward is buried at Auburn. Franklin's grave and the tombstone covering his and his wife's remains, may be seen from the sidewalk through an iron fence panel in the wall of the graveyard of Christ church, in Philadelphia. John Dickinson, "the Pennsylvania Farmer," has an almost umarked grave in the Friends' burying-ground at Wilmington, Del. General Wayne's remains, exhumed at Erie, in the old fort, and brought by his son over the mountains in a box seventy-five years ago, are in the old church at Radnor. Alexander Hamilton lies in the Trinity churchyard, New York, with a monument above him. Joseph Rodman Drake's remains lie in a private graveyard of the Hunt family, on Long Island Sound, near New York. Joseph Jefferson, the elder, lies buried in the Harrisburg cemetery, with an epitaph by Chief Justice Gibson. Francis Scott Key, who wrote the "Star Spangled Banner," is buried in Mount Olivet cemetery, at Frederick, Md. James Gates Percival is buried at Hazel Green, Mich. The tomb of Wilson, the ornithologist, is in the churchyard of the old Wicaco Swedes' church, at Philadelphia.—*Philadelphia American.*

It appears, that up to date, no fewer than 376 horses have trotted a mile (on a regular track) in two minutes and twenty seconds, or less. When Flora Temple made her record of 2:19¾, some thirty years ago, she was considered a marvelous horse. It was not denied that this record might be beaten, but it was believed that it would stand for a long time. The particulars of the record, as taken from the *Sun's* list, are as follows: 155 horses have a record of 2:20, or a fraction of a second less; 87 have a record of 2:19, or a fraction of a second less; 55 have a record of 2:18, or a fraction less; 27 have a record of 2:17, or a fraction less; 19 have a record of 2:16, or a fraction less: 12 have trotted in 2:15, or a fraction less; 9 in 2:14, or a fraction less; 4 in 2:13, or a fraction less; 2 in 2:12, or a fraction less; 4 in 2:11, or a fraction less; 1 in 2:10; and the peerless Maud S. has a record of 2:08¾.

A Kansas farmer recently sent this rather mixed order to a merchant in the county town: "Send me a sack of flour, five pounds of coffee, and one pound of tea. My wife gave birth to a big baby boy last night, also five pounds of corn starch, a screw-driver, and a fly-trap." — *The Ætna.*

The Locomotive.

HARTFORD, JANUARY 15, 1891.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

THE LOCOMOTIVE *can be obtained free by calling at any of the company's agencies.*

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Papers that borrow cuts from us will do us a favor if they will plainly mark them in returning so that we may give proper credit on our books.

A HAPPY New Year to you! And may 1891 be as prosperous in every way as 1890.

THE newspaper reporter is a particularly interesting creature when he undertakes to write up a boiler explosion. In an account of one of the November explosions, we read that "from what can be learned, the boilers were low when the water was turned on, and the person in charge neglected to turn it off, with the result that the boilers overflowed and exploded." In another instance, we find a "scare" heading: "Hurled to Death by a Boiler Explosion — Tracked by Blood and Brains — Human Mutilation Marked the Course of the Boiler." This is followed up by an account of the course the boiler took, which, it is affirmed, "was marked by blood, brains, and pieces of clothing."

WE have received from Messrs. John Wiley & Sons, of 53 East Tenth street, New York, a copy of a portion of Dr. Julius Weisbach's *Mechanics of Engineering and Machinery.* The present volume, which brings the work up to page 1,084, constitutes the second section of the first part of the third volume. It is translated from the German by J. F. Klein, professor of mechanical engineering at Lehigh University. Weisbach's treatise is well known and highly esteemed among engineers, and the present edition is also highly creditable both to the translator and the publishers. The fourth chapter, which opens the present volume, is devoted to ropes and chains, and contains an interesting examination of the process of hemp and wire rope-making, and the condition of the completed ropes. A large amount of information concerning the strength of ropes is also given, including a number of tables of experimental results. The chapter concludes with a study and comparison of chains and pulleys. Chapter V deals with screws, discussing different forms of threads, and suggesting the different uses to which screws may be put. A review of right and left-handed screws, differential screws, endless screws, and screw wheels follows, and the chapter closes with notes on the dimensions of screws and nuts. Chapter VI is devoted to crank trains, a great variety of which are considered and discussed. The influence of the inertia of reciprocating parts, and the effect of the length of the connecting rod, are considered, and multiple cranks are examined. In Chapter VII, a great variety of cams are discussed, and Chapter VIII is devoted to engaging and disengaging gears and escapement. Chapter IX comprises 154 pages on governors and motion regulators of all kinds. The volume closes with an appendix on the graphical statics of mechanisms.

It is our sad duty to record the death of Mr. Albert D. Baith, which occurred on December 16th, at his home in Cleveland, Ohio. Mr. Baith was only 28 years of age, but he had been in the employ of this company as special agent, for nearly seven years. He was an estimable young man, courageous, sincere, and methodical in all his business relations, and enjoyed the confidence and respect of all who knew him. His pleasant ways won him a large circle of friends, and his loss will be keenly felt both in business and social circles.

The Interior of the Earth.

The weight of a mountain of rock is prodigious, and it has supplied us with a figure of speech. We speak of "faith that will move mountains," meaning thereby, that it is exceedingly strong. Yet, when we think of the vast quantity of rock that the earth is composed of, and try to imagine the crushing force that this would exercise on a body placed at the earth's center — under four thousand miles of rock — the mountain seems feather-like in comparison.

In the sixty-third volume of *Crelle's Journal*, Herr Lipschitz gives, as the law of the increase of density of the earth, from the surface to the center,

$d = 9.453 - 6.953\,x^{2.39}$, where x is the mean radius of any homogeneous stratum, the mean radius of the earth being unity. (Our readers will please forgive us for putting in this equation; we don't often sin in that direction.)

Assuming Herr Lipschitz's theory to be correct, several very interesting facts follow from it. For example, it may be shown that the force of gravity is not greatest at the surface, as it would be natural to suppose, but that it is strongest .128 of the way from the surface to the center, that is, about 1,000 miles down, its value at that point being 1.0409 times its value at the surface. Also, it appears that the specific gravity of the material at the center of the earth is 9.453, or about one and a quarter times that of cast-iron. Furthermore, it is not a difficult matter to calculate, from the equation given above, the pressure at the center of the earth. We shall find it to be about 82,423,000 pounds to the square inch! This is truly appalling. To get some idea of the magnitude of this pressure, let us take one or two familiar examples. It is found by experiment, that the freezing point of water is lowered 0.0133° Fah. for each atmosphere of pressure exerted upon it. Assuming this to hold true throughout enormous ranges of pressure (though of course it does not), we find that at the center of the earth, the freezing point of water would be 73,062° Fah. below zero! We may be reasonably sure, therefore, that water could not exist at the center of the earth in the form of ice. Similar considerations will show that if Rankine's equation between temperature and pressure is correct for all ranges of temperature, it would not be possible, by any degree of heat, to convert it into steam, even an infinitely high temperature being insufficient.

An interesting bit of speculation is suggested by the foregoing. Although the melting point of ice is lowered by pressure, the melting point of rock is raised by it, so that in the deep interior of the earth, rock may have so high a melting point that it remains unmelted even at a very great heat. It does not follow, therefore, from the increased temperature as we go down into the earth, that its interior is in a liquid condition.

But it is almost meaningless to talk about the solidity or fluidity of the interior of the earth, for the awful pressures and the high temperatures that undoubtedly prevail there must bring matter into a condition of which we know nothing — which is neither solid nor liquid, nor gaseous. Sir William Thomson has shown, however, that the earth must, on the whole, be about as rigid as steel, or the sun and moon would give rise to tides in the planet itself.

The Founder of Inebriate Asylums.

A sketch of the late Dr. J. Edward Turner, founder of the first inebriate asylum in the world, has been published by T. D. Crothers, M.D., in *The Quarterly Journal of Inebriety.* Dr. Turner was born in Maine, in 1822, and had his mind turned to the subject of his life work by being called upon to take care of an inebriate uncle at intervals of several months, during his student life and after he began to practice medicine. When he first mentioned his idea of an asylum, where such cases could be secluded, housed, and treated, it was received with derision and contempt. He went to Europe in 1843, and spent two years in visiting hospitals and asylums, and discussed his ideas with medical men. On his return he began the systematic collection of facts concerning inebriety. About this time Drs. Valentine Mott and John W. Francis became interested in his plan for an asylum, and continued all their lives to be his warmest friends. There was much bitter opposition to the idea of treating drunkenness as a disease, and still more indifference to the matter, so that Dr. Turner made but slow headway. In 1848–'49 he made a second visit to Europe. After his return he began to solicit subscriptions to the stock of a company to build an inebriate asylum. A charter was obtained from the State of New York, and finally, in 1858, ground was broken at Binghamton for a building planned by Dr. Turner, and the erection of which he personally superintended. By persistent petitioning he obtained from the New York legislature a grant of one tenth of the money obtained each year from liquor licenses, for the building and maintenance of the asylum. In 1862 Dr. Turner married. The building had progressed far enough in 1864 to open it for patients, and a number of inebriates were admitted. At this point success seemed to have crowned the efforts of the founder. He had won over public opinion to his side, and the most active interest was being manifested all over the State in the work. But trouble arose over the mode of treatment. Dr. Turner's system was military in its strictness, his first principle being, that the asylum officers should have full control of the patient, and that this control should extend over a long time, and not be governed by the will of the patient or his non-expert friends. An unscrupulous, money-making lawyer in the board of directors and a weak president of the board caused a division, which was followed by persecution of Dr. Turner, and his resignation as superintendent in 1867. The asylum was then sold to the State for a nominal consideration, and thirteen years later was changed to an insane hospital, being known now as the New York State Insane Asylum at Binghamton. The transfer was not legally made, and Dr. Turner began a suit for the possession of the property, which was never carried to an issue. Dr. Turner then undertook to raise subscriptions for a woman's hospital for inebriates and opium-eaters. After three years, the subscriptions in money and materials had reached a great amount, ground had been broken for a building, when the legislature of Connecticut crushed the scheme by repealing the charter previously granted. For the next two years after this discouraging defeat Dr. Turner occupied himself in writing a book called the History of the First Inebriate Asylum in the World, which was a general account of his forty years' efforts. He then started out to sell the work, and to solicit aid to push his suit for the Binghamton asylum, and was busied thus when he died, July 24, 1889. Dr. Turner's career was a striking example of overwhelming defeat for the individual, joined with signal triumph for his idea. Inebriety is being more widely recognized as a disease each year. There are to-day over one hundred inebriate asylums in the world, all the direct result of his efforts in founding the first one at Binghamton.—*Popular Science Monthly.*

Our American Sahara.

The "Valley of Death." Long before a white man ever looked upon the direful spot the Indians of California and Nevada knew it by that name. Of the exploring expedition which the United States government is about to send thither some notice has been given briefly. It ought to be of interest to learn just what the purposes of this exploration are and the manner in which it is to be conducted. One point worth mentioning, to begin with, says a Washington correspondent of the St. Louis *Globe Democrat*, is that it will be made by the best equipped biological party that ever started out upon a scientific enterprise, including an unparalleled number of distinguished experts in ornithology, mammalogy, botany, entomology, and so forth.

Before going any further, it may be as well to give some general description of the extraordinary region which these men are about to investigate. From the Nysatch mountains to the Sierra Nevada extends a region of ghastly desert, nearly all of its area in the State of California, though to the east it reaches over the line into Nevada. This frightful waste is intersected by a series of high mountain ranges running parallel north and south, with valleys between. A birds-eye view of the landscape shows three principal ranges, the Inyo and Argus mountains forming the most westerly one, the Paramint being the next range to the east, and the Amargosa the third, still more easterly. East of the Amargosa range is the Amargosa desert, and between the Amargosa and the Paramint ranges is what is known as the "Death Valley," so called because of death and despair it is the very abode, the like of which is not to be found elsewhere in the world.

Imagine a narrow strip of arid plain, shut in between two mighty mountain walls, the peaks stretching up 10,000 feet into the burning sky. So precipitous are these rocky barriers that in a journey of fourteen miles you pass from an eminence of two miles above the sea level to the plain, 175 feet below the ocean tide-mark. The surface of this plain is composed of salt and alkali, and it is impossible to go over it on horseback because it is a mere crust through which the animal would break in up to his knees in a thick alkali paste which eats both hair and hide. There are paths by which one may make one's way across it if one knows where to find water on the opposite side. There is something unearthly about the whole appearance of things in the valley,—the two ranges of gigantic peaks that hem it in between them looking like the back-bones of a couple of monstrous beasts, and a gray haze that never lifts making everything indistinct to the view. No vegetation is to be seen, save a very scanty sage brush, with leaves that are not green but gray, with here and there a tall cactus which looks in the night like a dead man standing erect with arms extended. But the supreme horror of the place is the heat, which is unspeakable. There is a breeze, which, instead of being cool, is so scorching hot as to blister your face. Into this natural furnace the sun pours its rays, with never a cloud interrupting from one year's end to another. When the famous geologist, Professor Gilbert, succeeded in crossing the valley, nearly twenty years ago, barely escaping death from thirst, the thermometer inside his saddle-bag went up to 130 degrees and then burst.

A suggestive feature of the Death Valley landscape is the color of the mountain rocks, which are actually sunburnt to an iron-brown hue. Chip off a little flake, and you find the stone of its natural lighter hue underneath. Streams flow from mountain springs down towards the valley, but never reach it, because the heat dries them up on the way. Once in a great while there is a tremendous storm in the Amargosa desert to the eastward, and a river a mile in width flows from the desert around the south end of the Amargosa range and northward through the valley. Does it flow out again at the other end? Not much. It is dried up and lost before it gets that fa

Such is the Valley of Death—itself simply the most horrible spot in that great region of despair. The object of the government in exploring it is simply to learn what kind of animals live there. This enterprise is part of a great work which the department of agriculture has been for some time carrying on the purpose of which is to map out the whole United States into what are called "faunal areas." For example, suppose it be determined what are precisely the limits of the area occupied by the jackass rabbit. When that much is known it must necessarily be true that any plant which thrives in one part of that area will do well in any other part. There is such an intimate relation between animal life and plant life in this world, that, having found out the various areas inhabited by different birds and mammals, you have learned just where each form of vegetable growth can be produced to advantage. When the government has completed this important task, the farmers of the country will have placed before them maps, outlining with the closest accuracy the regions within which each kind of vegetable or fruit is susceptible of profitable cultivation. Thus the agriculturist, wherever he may be located, will know with certainty what he ought to plant. But the work of outlining the areas occupied by the animals of the United States will not be complete until the fauna of every part of the country, even to the highest mountains and most of the hopeless deserts, have been investigated. Last year an expedition was sent out to the astonishing San Francisco mountain, which uplifts its gigantic peak, three miles high, from the burning plains of Arizona, its top covered with perennial snows. Ascending its rocky precipices the explorers passed from a semi-tropical to an arctic clime, just as they would have done if they had traveled northward a few thousands of miles. Each cone had its own vegetation and forms of animal life suitable to the temperature. This same party that visited this mountain also explored the famous "Painted desert" near by, which gets its name from the fact that the queer looking hills, scattered all over the plain, where the sea, which once was there, has washed their sides away, are of all colors of the rainbow, with heaps of fossil wood on their surface.

The man who conducted the explorations will likewise have charge of the Death Valley expedition. He is Dr. C. Hart Merriam, chief of the division of mammalogy in the department of agriculture. With him will be Dr. Vernon Bayley, who ranks as the best collector of mammals in the world. Also in the party will be the eminent naturalist, Professor T. S. Palmer, likewise Dr. A. K. Fisher, assistant ornithologist of the department: E. V. Coville, assistant botanist; E. W. Nelson, a well-known naturalist and topographer; and Professor Stephens, a distinguished expert in mammalogy and desert work. There will also be two or three other assistants with the party, which will necessarily be accompanied by a small corps of mule-packers and other servants.

At the beginning the expedition will be divided into two parties. One of these is now at Owen's Lake, in California, on the point of starting out. It is under the command of Vernon Bayley, and will begin work at the foot of Inyo range, to the west of which Owen's Lake is. Bayley will not go far, however, until joined by Palmer with the other party. Palmer will leave Washington within less than a week, with instructions to take charge of the entire expedition until Dr. Merriam goes out to the scene of operations early in March. Upon leaving Washington, Palmer will go straight to San Bernardino, Cal., where he will outfit with a six-mule team, pack animals and supplies. Fisher, Coville, and Stephens will accompany him; Nelson is at Owen's Lake with Bayley. When Merriam goes out, he will be accompanied by an expert from the entomological division to look up bugs. The two parties will meet at Paramint, a small mining village in the Paramint range, and work will then begin in earnest, the manner of prosecution being this:

Each party will have a wagon, which it will utilize as a base of operations, leaving it at a spot where there is water, and making excursions of a few days each, with pack mules to carry the baggage and provisions. For convenience in this method of procedure, the expedition will naturally divide itself up into half a dozen little parties, a naturalist, a packer, and a mule or burro, making a very effective working gang. The amount one mule can carry is simply astonishing, but men have to be specially hired for their expertness in the art of packing. To "throw the diamond hitch" is the main requirement. With the assistance of this extraordinary knot, properly tied, a mule can easily get along all day over rough country with two 150-pound sacks of "sourbelly" pork, one sack of flour, a chest of drawers for specimens, a tank of alcohol, a couple of beds, etc.

The first thing done will be to locate all the places where water is to be found. Hundreds of people have lost their lives in Death Valley through starting off in the morning without knowing where they were going to find water at night. There will be no such foolishness as that indulged in by the expedition. With every precaution a sufficient amount of suffering will, of necessity, have to be undergone. Water is the great desideratum in that horrible place, where the air is much drier than that of the Sahara, and the heat so great as to put the body through a sort of evaporating process, such as that to which a dried apple is artificially subjected. So rapid is this evaporation of the bodily moisture that three gallons of water a day are absolutely necessary for each individual, instead of the three pints one ordinarily consumes.

If one were to sit down in the desert all day long and do nothing but drink water, he would still feel thirsty. Even with a supply of three gallons a day, the blood of the traveler across the waste becomes thickened, the features grow thin and peaked, dreadful constipation sets in, and fever threatens madness. In crossing the valley one cannot very well carry with him more than enough water for one day's supply. The only way to do is to hurry over and try to reach the other side—only about fifteen miles distant—before one succumbs for want of drink. If you know precisely in which of the gorges of the mountain springs are to be found, it is well enough, but if you are not certain on the point, you are likely to become so exhausted, after traveling up to the heads of one or two gorges fruitlessly, as to find nothing better to do than to lie down and die the most horrible of deaths.

You will not need burial, for your body will not decay, but will simply be shriveled up to a mummy, and lie there in the Valley of Death to an eternity, imperishable, staring up at the burning sky. Here and there, all over the awful plain of salt and alkali, are scattered the dead bodies of men and animals preserved for all ages to come. During the mining fever in that neighborhood, from 1872 to 1878, hundreds of people were lost in trying to get across. You may have heard of an "alkali sink." That is what Death Valley is. As has been said, the plain of the valley is below the level of the sea, and the alkaline river flowing into it at certain seasons from Amargosa desert deposits its alkali in the crust, through which the foot in stepping breaks into the abominable paste beneath.

It will be the work of the expedition to kill and capture every sort of living creature that can be found in Death Valley and its surrounding region. Every specimen of animal life to be discovered there will be represented by from a dozen to a score of specimens, in the collection which will be brought back to Washington.—*Hartford Post.*

The Locomotive.

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The History of a Laminated Steel Plate.

Some time ago a boiler in the South gave out in a very peculiar way. The material of which it was composed was supposed to be steel, which material, being rolled from ingots, rarely shows signs of lamination. The cuts presented herewith are made directly from photographs of the sheet, which was removed from the boiler and sent to us by the owner for explanation. Some correspondence with the builders of the boiler and the makers of the steel plate followed, and perhaps the story of the plate can be best told by making a few extracts from this correspondence, withholding the names.

On October 23, 1889, we wrote to the builders of the boiler as follows: "On receipt of your letter we sent for the piece which was cut out of the boiler, and since its arrival we have examined it very carefully. It is a very peculiar accident that happened to the sheet, and yet perhaps it would not be unexpected if our theories in regard to it are correct. A careful examination reveals to us what appears to be an effort on the part of the maker of the plate to roll two thin sheets of steel together in order to make the proper and required thickness of plate. The lamination extends back 8 or 10 inches, and it has every appearance of having been caused by an attempt, as above suggested, to roll two plates together. We have had careful photographs taken of it, a set of which we enclose to you. We have never known but one instance before of lamination in a steel plate, and that was caused by rolling the ingot down and not trimming off the overhanging portions on the end. That was easily accounted for, but the one in question is a very peculiar case, indeed. We would send you the plate itself, but it is such a valuable specimen to us that we do not like to part with it." Two days later a reply came, saying, "We note that you say it appears to you that the maker of the plate attempted to roll two thin sheets of steel together in order to secure the proper and required thickness of plate. This

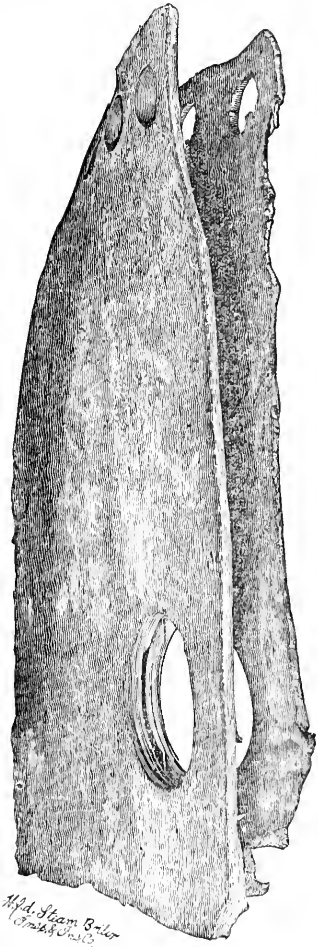


Fig. 1.—A Laminated Steel Plate.

is hardly probable, as any maker would know it *could not be done;* and all this steel is rolled from a solid ingot, and never 'piled.' The explanation, instead of being as you make it, would appear to be, that there was a shrink hole or cavity in the ingot that did not show itself from the outside, and that in rolling this was spread. If you can give us the name of the maker of the steel, we will then submit the photographs and your letter, and hear what they have to say." We forwarded the name of the plate-maker, and added, under date of November 1st, that "we did not wish to be understood as saying that *it is* the result of two plates being rolled together, but that it had very much that appearance. There is apparently a scarf joint on one piece, and there are peculiar features about it which we are unable to explain on the ground that it is the result of the overhanging horns of the ingot. There are, in our judgment, no indications of a shrink hole or cavity having been in the ingot. It is such an interesting specimen that we are loth to have it go from this office; but if we can be assured that it will be returned to us, we shall be glad to send it to you. The manufacturers of the steel may be able to give some explanation of it, but it is different from anything that we have ever seen before."

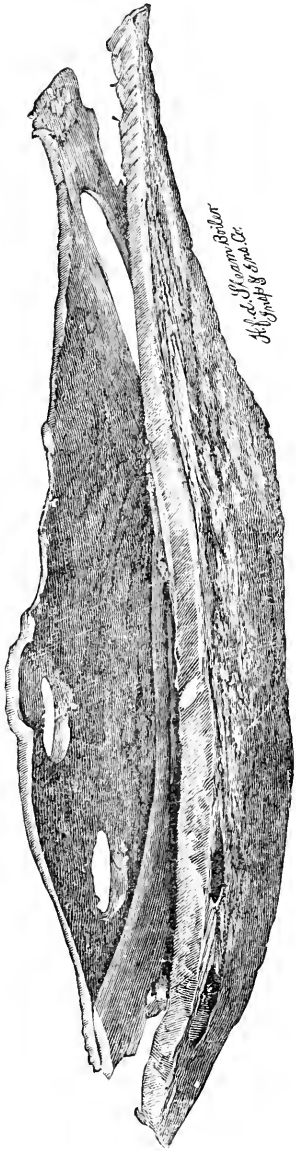


FIG. 2.— A LAMINTATED STEEL PLATE.

The builders of the boiler having communicated with the plate-maker, that latter wrote us as follows on November 7th: "We are in receipt of the photographs you made of it; but, in the interest of a thorough examination which we wish to make, both for our own benefit and for the information of our patron, we should like very much to have the piece of plate. As a matter of fact, we have never tried to roll two thin plates together, and are at a loss to account for the splitting that has occurred. We think the appearance or composition of the plate will probably throw some light on the subject, and would consider it a special favor if you will kindly express the plate to us."

On November 13th, we sent the plate, saying that "it looked as though an effort had been made to roll two plates of thin steel together. We did not wish to be understood as saying that this *was* done, but that it had very much that appearance. We cannot explain nor understand how this very peculiar feature could have occurred from any blowhole or from any projecting portions of the ingot before rolling. This is such an interesting specimen that we dislike to part with it, as we have a large collection of specimens which we have collected in our twenty years of business, but we shall be perfectly willing to send it to you as you desire, only we ask that it be returned to us again. Not that we wish to make any use of it against the manufacturer of the steel; we wish it merely as a specimen of a peculiar condition of a steel plate. We send the piece by express to you with the urgent request that you return it to us after you have made such examination as you desire. We call your attention to what appears to be a seam running lengthwise of the piece in the thinner portion of the sheet. If you look upon the edge, you can see where it appears to have been scarfed and spliced; then on the inside there is a peculiar ridge, you will notice, which looks as though there had been an effort to weld two pieces together. Your experience in manufacturing steel plate may enable you to give some satisfactory explanation of this peculiar feature, and we shall be interested to know how you account for the defect."

A month later, on December 14, 1889, having no reply to the foregoing letter, we wrote the plate-makers as follows: "In reply to a request from you dated November 7th, we sent by express a piece of plate that was taken from a boiler in the South. This was a peculiar piece of steel, from the fact that it was laminated, and had peculiarities that made it entirely different from any piece of steel plate we had ever before seen. We sent this to you on November 13th, and requested that you give us your views as to the cause of the lamination. We have heard nothing from you in regard to it since. Did you receive it? and have you come to any conclusion with regard to it? If so, we shall be glad to hear from you, and to receive the piece of steel back again."

On December 16th, a reply to this letter was sent to us, as follows: "We find ourselves placed in such an unfavorable position, particularly when our conduct is compared with your treatment of us, that a reply at best can only show how blameworthy we are. The fact is, that this piece of steel, while in possession of our testing department, was by some disreputable means extracted from our sample case. Though we have made strenuous efforts to find it, or even to discover a clue that might lead to its discovery, we have been unable to get the slightest trace of anything that would indicate by whose carelessness or inattention it was lost. We can only ask you to pardon this breach, and say that we greatly desire some opportunity to reciprocate your favor and to make amends, as far as possible, for this most unsatisfactory termination of the correspondence this office has had with yourself. We cheerfully give the results of our investigation, which are as follows: "This was a case of peculiar lamination, the cause for which is beyond the ability of science to discover, or experience to give much light upon. To show that no examination could have shown the plate, when new, to have been faulty, we have only to direct your attention to the fact that the purchaser of the plate, in the course of constructing the boiler in question, punched, drilled, tapped, and riveted the plate without discovering it to be weak in any particular."

This is the history of the plate, so far as we know it. We have met with several similar plates since the foregoing correspondence was written, and we wish to say that the present article is not published for the purpose of injuring or throwing the least discredit upon the manufacturers of the plate in question. We merely wish to call general attention to this sort of defect, in order that the cause of the defect may be discovered, if possible, and the defect itself avoided in the future. Quite recently we have found a steel plate with a blister upon it covering an area fully thirty inches square, the two portions of the plate being of the same thickness and same general appearance.

We are told that the State of Michigan has amended its school laws, so that children suffering from consumption or chronic catarrh must be excluded from public schools. The public is gradually waking up to the fact that consumption is a contagious disease, the spread of which can be greatly lessened by suitable measures of precaution.

Inspectors' Reports.

NOVEMBER, 1890.

During this month our inspectors made 4,705 inspection trips, visited 9,253 boilers, inspected 4,298 both internally and externally, and subjected 561 to hydrostatic pressure. The whole number of defects reported reached 10,360, of which 627 were considered dangerous; 37 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	765	33
Cases of incrustation and scale,	1,164	39
Cases of internal grooving,	45	9
Cases of internal corrosion,	304	13
Cases of external corrosion,	718	41
Broken and loose braces and stays,	120	19
Settings defective,	298	21
Furnaces out of shape,	422	14
Fractured plates,	230	55
Burned plates,	179	13
Blistered plates,	276	4
Cases of defective riveting,	2,686	42
Defective heads,	76	19
Serious leakage around tube ends,	1,725	151
Serious leakage at seams,	467	21
Defective water-gauges,	224	28
Defective blow-offs,	103	20
Cases of deficiency of water,	16	6
Safety-valves overloaded,	51	22
Safety-valves defective in construction,	48	19
Pressure-gauges defective,	327	30
Boilers without pressure-gauges,	3	3
Unclassified defects,	113	5
Total,	10,360	627

DECEMBER, 1890.

During this month our inspectors made 5,807 inspection trips, visited 10,931 boilers, inspected 4,137 both internally and externally, and subjected 684 to hydrostatic pressure. The whole number of defects reported reached 10,779, of which 887 were considered dangerous; 31 boilers were considered unsafe for further use. Our usual summary is appended:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	650	29
Cases of incrustation and scale,	1,103	29
Cases of internal grooving,	42	10
Cases of internal corrosion,	348	20
Cases of external corrosion,	765	29
Broken and loose braces and stays,	115	20
Settings defective,	293	25
Furnaces out of shape,	366	16
Fractured plates,	232	99
Burned plates,	184	36
Blistered plates,	220	8
Cases of defective riveting,	2,715	59

Nature of Defects.	Whole Number.	Dangerous.
Defective heads,	87	7
Serious leakage around tube ends,	2,211	310
Serious leakage at seams,	428	35
Defective water-gauges,	269	27
Defective blow-offs,	118	30
Cases of deficiency of water,	21	9
Safety-valves overloaded,	66	12
Safety-valves defective in construction,	88	25
Pressure gauges defective,	318	43
Boilers without pressure gauges,	9	9
Unclassified defects,	131	0
Total,	10,779	887

Summary for the Year 1890.

During the year our inspectors made 61,750 visits of inspection, examined 118,098 boilers, inspected 49,983 boilers, both internally and externally, subjected 7,207 to hydrostatic pressure, and found 402 unsafe for further use. The whole number of defects reported was 115,821, of which 9,387 were considered dangerous. A summary of the work by months is given below, and the usual classification by defects is likewise given.

Summary by Months.

Month.	Visits of inspection.	Number boilers examined.	No. inspected internally and externally.	No. tested hydrostatically.	Number condemned.	Number of defects found.	Number of dangerous defects found.
January,	5,119	10,693	3,907	506	49	8,622	752
February,	4,652	9,182	3,883	548	36	7,898	739
March,	4,842	9,675	3,529	616	34	8,939	568
April,	4,334	7,874	3,755	618	39	7,732	878
May,	6,013	11,217	4,626	662	33	11,708	936
June,	5,099	9,448	4,172	646	24	11,277	888
July,	5,146	10,724	5,206	583	33	10,191	793
August,	4,932	8,555	4,165	417	28	9,462	731
September,	5,379	9,592	4,264	667	39	9,272	694
October,	5,722	10,954	4,041	699	19	9,581	894
November,	4,705	9,253	4,298	561	37	10,360	627
December,	5,807	10,931	4,137	684	31	10,779	887
Totals,	61,750	118,098	49,983	7,207	402	115,821	9,387

Summary by Defects for the Year 1890.

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	7,250	378
Cases of incrustation and scale,	12,113	436
Cases of internal grooving,	711	105
Cases of internal corrosion,	3,938	284
Cases of external corrosion,	8,242	476
Defective braces and stays,	1,462	423
Settings defective,	3,132	298
Furnaces out of shape,	4,347	164
Fractured plates,	2,098	670

Nature of Defects	Whole Number.	Dangerous.
Burned plates,	1,975	263
Blistered plates,	3,209	148
Defective rivets,	26,481	722
Defective heads,	995	254
Leakage around tubes,	23,246	2,493
Leakage at seams,	4,863	361
Water gauges defective,	3,087	411
Blow-out defective,	1,074	243
Cases of deficiency of water,	218	106
Safety-valves overloaded,	535	159
Safety-valves defective,	795	254
Pressure gauges defective,	3,626	361
Boilers without pressure gauges,	163	163
Unclassified defects,	2,261	215
Total,	115,821	9,387

Summary of Inspectors' Work Since 1870.

Year.	Visits of inspection made.	Whole number of boilers inspected.	Complete internal inspections.	Boilers tested by hydrostatic pressure.	Total number of defects discovered.	Total number of dangerous defects discovered.	Boilers condemned.
1870	5,439	10,569	2,585	882	4,686	485	45
1871	6,826	13,476	3,889	1,484	6,253	954	60
1872	10,447	21,066	6,533	2,102	11,176	2,260	155
1873	12,824	24,998	8,511	2,175	11,998	2,892	178
1874	14,368	29,200	9,451	2,078	14,256	3,486	163
1875	22,612	44,763	14,181	3,149	24,040	6,149	216
1877	....	32,975	11,629	2,367	15,964	3,690	133
1879	17,179	36,169	13,045	2,540	16,238	3,816	246
1880	20,939	45,166	16,010	3,490	21,033	5,444	377
1881	22,412	47,245	17,590	4,286	21,110	5,801	363
1882	25,742	55,679	21,428	4,564	33,690	6,867	478
1883	29,324	60,142	24,403	4,275	40,953	7,472	545
1884	34,048	66,695	24,855	4,180	44,900	7,449	493
1885	37,018	71,334	26,637	4,809	47,230	7,325	449
1886	39,777	77,275	30,868	5,252	71,983	9,960	509
1887	46,761	89,994	36,166	5,741	99,642	11,522	622
1888	51,483	102,314	40,240	6,536	91,567	8,967	426
1889	56,752	110,394	44,563	7,187	105,187	8,420	478
1890	61,750	118,098	49,983	7,207	115,821	9,387	402

In order to exhibit the growth of the company's business, we append a summary of the work of its inspectors from 1870 to 1890, inclusive, omitting the years 1876 and 1878, for which we have not the precise figures at hand. We may say, however, that the figures for these years fall in with the regular progression observable in the other years. Previous to 1875, it was the custom of the company to publish its reports on the first of September, but in this year the custom was changed and the summaries were made out up to January 1st, so as to agree with the calendar year. The figures given opposite 1875, therefore, are for the sixteen months, beginning September 1, 1874, and ending December 31, 1875.

The following table is also of interest. The total number of inspections made by this company passed the million mark a year ago. Another year will probably bring the total number of defects discovered close up to a million, and the number of dangerous defects that we have detected and called attention to will, no doubt, exceed an eighth of a million, to which figure it is now very close:

Grand Total of the Inspectors' Work Since the Company Began Business, to January 1, 1891.

Visits of inspection made,	568,764
Whole number of boilers inspected,	1,130,388
Complete internal inspection,	424,893
Boilers tested by hydrostatic pressure,	78,890
Total number of defects discovered,	835,148
" " " dangerous defects,	119,796
" " " boilers condemned,	6,602

Boiler Explosions.

December, 1890.

Quarry (189). At 7 o'clock on Monday morning, Dec. 1st, the boiler of Thomas Beck's slate quarry between Walnutport and Lockport, Pa., and a mile from Lehigh river, exploded with terrific force. It was a forty-horse power cylindrical boiler, and had been regarded entirely safe. The cause of the explosion is unknown. The engineer, whose name could not be learned, was seriously scalded.

Saw-mill (190). Berwick, Pa., was the scene of a shocking boiler explosion on Dec. 2d. Four men were killed, and a saw-mill plant, including the stable and surrounding buildings, was burned. The accident occurred at four o'clock, when a great outburst of steam at Adams' saw-mill was followed by a terrific report. Nothing remained of the little hamlet that had been built for the lumbering men, and its four inhabitants were strewn about the woods dead. Ira Gruver, one of the employes, was found dead about fifty feet from where the boiler-house stood. His brother was found in another direction, and two other men, their companions, lay in the saw-pit without mutilation, but dead. Examination of their bodies showed them to have sustained fractures of the skull and internal injuries from which they must have died almost immediately. What caused the explosion is a mystery ; the boiler, it is said, was quite new and in first-class condition. The mill was situated on Nescopeck Mountain, some distance from the town, and was surrounded by dense woods. The loss of property will reach several thousand dollars.

Oatmeal Mill (191). A five-inch plug blew out of the boiler at an oatmeal mill in Rockford, Ill., on Dec. 2d, and for a time it looked as though a serious fire would follow. All of the brick work around the boiler was blown away by the force of the escaping steam.

Paper Mills (192). The extensive paper mills of J. A. Muir & Son, a mile and a half from Morristown, N. J., were destroyed by fire on Dec. 2d. The buildings being in an isolated spot, no firemen could reach the scene in time, although plenty of water was within easy reach from the Whippany river, which runs by the property. During the progress of the blaze the boiler exploded, severely injuring several men who were endeavoring to save some of the property. The loss will exceed $25,000.

SAW-MILL (193). On Dec. 3d, Messrs. Tanner and Waldrop left their saw-mill, at Douglasville, Ga., for a while. It is said that several boys entered the mill during their absence, and in fooling with the boiler drew most of the water out of it. They left the boiler in this condition and skipped away without letting any one know what they had done. The workmen returned to the mill, and, thinking it was all right, built a fire in the furnace. All of a sudden there was a terrible explosion, the boiler was blown to pieces, and the mill damaged a great deal. A negro named McLarin was killed almost instantly, a white man named Hunter had his leg broken and Mr. Waldrop was bruised up considerably. [We give the account as we find it in the *Atlanta Journal*, but we may perhaps be allowed to say that it sounds very fishy.]

SAW-MILL (194). Three eighty horse-power boilers at the saw-mill of N. Byers & Co., a Williamsport and Lancaster firm operating in Columbia, Pa., exploded on Dec. 6th, completely wrecking the building. Devoy Tousey of Williamsport was fatally scalded. Christian Singer of Columbia may die from his injuries. William Sleer, the engineer, was scalded, but not seriously. The loss will be between $1,500 and $2,000.

LOCOMOTIVE (195). As the 8.30 Lehigh Valley freight train, east bound, was passing Dale, six miles west of Warsaw, N. Y., on Dec. 8th, the boiler exploded, killing the engineer and fatally injuring the fireman. It is supposed the engineer was about to take water at that station. The boiler was lifted from its trucks and carrried backward some 80 feet, landing between the main track and the siding. The tender and trucks did not leave the rails. The engineer's body lay under the boiler. Charles C. Ryan and William McDonald, train hands, were seriously injured, but probably not fatally.

LOCOMOTIVE (196). Freight engine No. 432, of the Philadelphia & Reading railroad, blew up, on Dec. 7th, while standing in the roundhouse at Twentieth street and Pennsylvania avenue, Philadelphia, but fortunately nobody was hurt. The engine was completely demolished, and the entire side of the building was blown out, involving a loss of about $9,000. The force of the explosion was terrific. The cab was blown to the roof of the roundhouse, and fell back in fragments. The piston-rods and heavy axles of the engine were twisted, and all the lighter portions of the machinery were scattered over the building. Engine No. 160, which was standing on an adjacent track with steam up, was derailed, her cab blown to pieces, and the machinery badly damaged.

LOCOMOTIVE (197). The boiler of a locomotive of a freight train exploded, at Wallingford, Conn., on Dec. 9th, with tremendous force. The great plates of iron were rent asunder and heavy pieces were blown for distances varying from 150 to 300 feet; the sand box, weighing over 100 pounds, was raised into the air many feet, and fell upon the roof of Patrick McNulty's house, which stands about fifty feet away, crushing into the garret ; one of the big driving wheels was blown completely off, and the tubes inside the boiler were bent and twisted. One side of the cab was utterly wrecked. Engineer Kennedy and Fireman Carroll were thrown from the cab, but not seriously injured.

ARMORED CRUISER (198). At about 10 o'clock on the morning of Dec. 9th, the workmen on the new armored cruiser *Maine*, in Brooklyn, were startled by a loud explosion on the deck of that vessel, accompanied by a noise of escaping steam and immediately followed by a shower of hot ashes. They at once made a rush for the side of the vessel, reaching the ground almost before the noise of the explosion had died away. When things had quieted down a bit, they returned and found that the cause of the commotion had been the explosion of the boiler of a hoisting engine which is stationed on the deck. Several of the tubes of the boiler had been broken by the explosion, and the upper head and smokestack were blown off. Engineer E. J. Sheridan, who was making some repairs to the boiler at the time of the accident, was the only man injured, but he was so badly burned about the hands and face that he had to be sent home.

Saw-mill (199). The boiler of J. W. Lee's saw-mill, about three miles from Mountain Lake Park, near Wheeling, W. Va., blew up on Dec. 11th, instantly killing John King and dangerously injuring John P. Ours, Kingsley Lee, and James List. The accident was caused by a fractured plate.

Saw-mill (200). One of the boilers in Hoye's saw-mill, at Hodge, Texas, exploded on Dec. 12th, blowing a portion of the boiler fully 40 yards. Alex. Hart, the fireman, was the only one near when the explosion occurred, the others having stopped for dinner. He crawled under the trimmer and saved his life. He was but slightly hurt. "The cause of the explosion," says the account, "was a defective boiler."

Saw-mill (201). The boiler of a small saw-mill at Tibbett's Siding, between Woodville and White Cloud, near Big Rapids, Mich., exploded on Dec. 13th. The engineer and two others were instantly killed, and two more were injured, probably fatally.

Turnbuckle Factory (202). The large upright boiler at the turnbuckle factory, operated by the Central Iron and Steel Company in Brazil, Ind., exploded at a few mintes before 7 o'clock on the morning of Dec. 23d. The steam was low, and the force of the explosion scarcely lifted the boiler in the air, though wrecking the furnace underneath it. The men had not all arrived for work, but two of them, Albert Rule and Joe Howard, were badly though not fatally scalded. The engineer was not in charge of his engine at the time of the explosion. But little damage was done to the buildings.

Salt Works (203). A boiler exploded in a drill-house at the works of the United Salt Company, on the lake shore, in the eastern part of the city of Cleveland, Ohio, on Dec. 24th. The boiler was broken into fragments, and the drill-house wrecked. Martin Schearney was killed, Frank Geiner perhaps fatally scalded, and Thomas Fox, the engineer, was scalded and both legs and one arm broken. Another man is missing, and it is feared that he was blown into Lake Erie.

Saw-mill (204). By the explosion of a boiler in Kelly & Wells' lumber mill on Black river, forty miles from Newport, Ark., on Dec. 25th, a number of men were wounded, and Engineer Wiley Sloan and John Angus, the superintendent, were killed. No traces of the body of Sloan can be found. A large section of the boiler was shot through the iron roof, then through the Texas deck of the steamer *Golden Gate*, anchored near by, and then across the river, 100 yards wide.

Dry Goods store (205). At about 10 o'clock A. M., on Dec. 26th, a flue in a boiler in George W. Newman & Co.'s dry goods store gave way, seriously, and perhaps fatally, injuring a cash boy named Nye Martin, who happened to be in the cellar at the time. Very little damage was done to the store, as the flames caused by the explosion were quickly quenched. Young Martin, after being hurt, crawled out of a back window. He was so blackened and his clothing was so scorched that he was unrecognizable until he spoke.

Sausage Factory (206). A disastrous boiler explosion occurred, on Dec. 27th, on the premises of Gus Lowenstein, Jr., butcher and manufacturer of sausages at Ninth and John streets, Cincinnati, O. There was a terrible upheaval in the vicinity, and no less than seven buildings occupied as dwelling-houses were wrecked and torn, so that they will have to be taken down. Bertha Gray, aged two years, was killed, being found under the debris of one of the houses. Mrs. Lowenstein has a broken back and cannot live; Mrs. Baum, her daughter, was badly cut and bruised. William Higgins' rib was broken, and he was badly bruised. Mike Kennedy was cut about the head, and Mrs. Gray and her daughter Jennie were both slightly injured.

FORGE WORKS (207). A terrific explosion occurred on Dec. 29th at Sizer's steam forge works on Mill street, Buffalo, N. Y. The boiler in the works burst and completely wrecked its setting. G. A. Hammond, the engineer, was just entering the boiler-room when the explosion occurred. He was hurled back several yards and was dashed to the ground with great force. His right leg was broken, and he sustained other injuries. He was taken to the Fitch Hospital. No reason has been assigned for the explosion.

Summary of Boiler Explosions for the Year 1890.

Our usual summary and classified list of boiler explosions during the year is presented herewith. So far as we have been able to learn, the total number of explosions was 226, against 180 for 1889. In several instances more than one boiler exploded at the same time. Where this has been the case we have counted each boiler separately, as in our summaries for 1888 and 1889, believing that by so doing we can give a fairer conception of the amount of damage done during the year. It is difficult to make up an accurate list of the killed and injured, as in many cases the newspaper reports (upon which we largely depend in making up our monthly lists) are rather indefinite. We have carefully examined the accounts of each explosion, however, and have done our best to make the summary as fair as possible.

CLASSIFIED LIST OF BOILER EXPLOSIONS IN THE YEAR 1890.

CLASS OF BOILER.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
1. Saw-mills and other Wood-working Establishments.	6	7	8	3	5	8	2	7	1	8	11	9	75
2. Locomotives.	3	3	1	1	3	...	...	3	5	3	...	3	25
3. Steamships, Tugs, and other Steam Vessels,	...	3	2	...	1	4	1	2	...	2	...	1	16
4. Portable Boilers, Hoisters, and Agricultural Engines,	1	...	1	1	...	4	2	1	3	1	2	...	16
5. Mines, Oil Wells, Collieries,	3	4	3	1	4	...	...	2	1	...	...	1	19
6. Paper Mills, Bleacheries, Digesters, etc..	...	...	...	...	...	1	...	1	...	...	...	1	3
7. Rolling Mills and Iron Works,	2	1	...	4	1	...	1	...	...	2	1	1	13
8. Distilleries, Breweries, Dye-Works, Sugar Houses, and Rendering Works,	...	2	...	...	...	...	...	1	...	...	...	...	3
9. Flour Mills and Grain Elevators,	1	...	1	...	...	...	1	...	...	1	...	1	5
10. Textile Manufactories,	...	...	...	...	1	...	...	...	...	...	...	...	1
11. Miscellaneous,	8	6	6	3	3	3	1	4	5	3	4	4	50
Total per month,	24	26	22	13	18	20	8	21	15	20	18	21	226
Persons killed (total, 244), " "	24	31	18	11	16	20	12	30	11	28	25	18	
Persons injured (total, 351), " "	44	38	44	19	21	37	12	38	10	32	36	20	

It should be understood that this summary does not pretend to include *all* the explosions of the year. In fact, it probably includes but a small fraction of them. Many accidents have undoubtedly happened that were not considered by the newspapers to be sufficiently "newsy" to interest the general public; and many others have, without question, been reported in local papers that we do not see.

We are pleased to report that although the number of explosions during 1890 has been greater than during 1889, the number of those killed and injured has been both relatively and absolutely less. The number of persons killed outright, or who died within a very short time, was 244 during 1890, against 304 in 1889, 331 in 1888, 264 in 1887, and 254 in 1886; and the number injured was 351, against 433 in 1889, 505 in 1888, 388 in 1887, and 314 in 1886.

There were no explosions during 1890 that approached the disaster at the Park Central Hotel in this city, on Feb. 18, 1889, or the destruction of the Mississippi steamer *Corona* on October 3, 1889. A saw-mill, near St. John, N. B., was destroyed by a boiler explosion on Nov. 25th, five workmen being instantly killed and eleven others wounded, two or three of them fatally. This was probably the most disastrous explosion of the year.

An Unusual Accident in a Boiler Room.

A peculiar accident came to our notice not long ago. A fireman had allowed the pressure in his boiler to go down at night, and had then opened the blow-off valve and gone home, leaving the boiler to empty itself during the night. In the morning he entered the boiler-room and closed the blow-off valve, as no water was escaping through it, and presumably there was none left in the boiler. He next loosened the front hand-hole plate and knocked it in. A considerable amount of air rushed in, and immediately afterward a stream of hot water burst forth, throwing the fireman against a wall opposite the front of the boiler, and scalding him severely.

The explanation of this strange action seems to be that there was little or no pressure in the boiler when the blow-off was opened, and no vent through which air could enter. The result would naturally be that water would escape through the blow-off until a partial vacuum was formed in the boiler. Then the flow of water would cease, and instead of an empty boiler when the blow-off was closed next morning, the fireman had a boiler nearly full of scalding water. Upon opening the hand-hole a considerable amount of cold air rushed in, owing to the partial vacuum inside. As this air bubbled up through the water it became heated and expanded so rapidly that the pressure in the boiler immediately rose sufficiently to force some of the scalding water out into the fireman's face. This is the explanation that seems to us most likely, though it must be confessed that one would hardly expect any very violent expulsion of water from such a cause.

A DISCOVERY of opals has recently been made near Moscow, in the State of Washington, close to the Idaho line. A number of the gems have been taken to New York and cut, and it is found that they show a more brilliant play of colors than those obtained from Mexico. They are whiter and without the yellowish tinge of the Mexican gems. Some of them appear to be harlequin opals, on which the patches of color are angular and variously tinted, but evenly distributed. Others show deep green flashes of color, like those called lechosos by the Mexicans. One, a very large specimen, has been examined by a skillful lapidary and by other competent persons, who are of the opinion that it is the largest and most valuable precious opal in the rough that has ever been seen in New York.—*Scientific American*.

The Locomotive.

HARTFORD, FEBRUARY 15, 1891.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

THE LOCOMOTIVE *can be obtained free by calling at any of the company's agencies.*

Subscription price 50 cents per year when mailed from this office.

Bound volumes one dollar each.

Papers that borrow cuts from us will do us a favor if they will plainly mark them in returning so that we may give proper credit on our books.

ONCE more it becomes our sad duty to announce the death of one who has been with us since the early days of the company's existence. Mr. John S. Wilson, who had long been chief inspector in our St. Louis department, passed away on January 24th, in Cincinnati. He first came with us as an inspector about 1871, and he has been with us ever since until about a year ago, when he was retired from active service on account of his age and increasing bodily infirmities. Mr. Wilson was educated as a mechanical engineer, and had had considerable experience in river engineering, and in locomotive and stationary engine work. He was for some time connected with the old Niles Bros. Locomotive Works in Cincinnati.

Tannin Matters as Scale Preventives.

A short time ago M. Vignon read a paper before the French Chemical Society, on the subject of "Anti-incrustators," the substance of which, as given in our esteemed London contemporary, the *Practical Engineer*, we reproduce below, with the metric numbers changed into their equivalents in our units.

Having had occasion to examine a number of mixtures sold as boiler-scale removers, M. Vignon remarked the presence, in many of them, of tannin matters, along with sodium carbonate (soda ash). One such mixture in particular was composed of (about) one quart of sumac extract (of a specific gravity of 0.87), and 14 oz. of anhydrous carbonate of soda to the gallon of water. For the purpose of discovering whether the tannin matter in the sumac extract was of use or not, M. Vignon instituted a series of experiments. Five pieces of clean boiler plate of the same size were weighed, and one being reserved for comparison, the other four were boiled for eight hours separately, in the following solutions :

Solution No. 1	Water	8 gallons.
Solution No. 2	Sumac extract Water to make	$1\frac{1}{5}$ fluid ounces. 8 gallons.
Solution No. 3	Carbonate of Soda Water to make	.53 ounce. 8 gallons.
Solution No. 4	Sumac extract Carbonate of Soda Water to make	$1\frac{1}{5}$ fluid ounces. .53 ounce. 8 gallons.

At the end of eight hours' immersion the samples of boiler plate were removed, rinsed, brushed, cleaned with fine sand, dried, and weighed. The effects of the various solutions are shown in the following table:

Solution.	Weight of boiler-plate before experiment (in ounces).	Weight after experiment (in ounces).	Loss of weight (in ounces).
No. 1	3.5418	3.5401	.0017
No. 2	3.3313	3.2980	.0333
No. 3	3.4653	3.4651	.0002
No. 4	3.6487	3.6353	.0134
Sample kept	3.4776	3.4773	.0003

With the river water the sample was slightly rusted; a deposit of carbonate of lime, mixed with some oxide of iron, was left in the bath. Sumac extract used alone caused the iron to become covered with a black coating of iron tannate, the bath being deeply colored. No trace of rust appeared on the iron when carbonate of soda alone was used. In the bath there was a slight deposit of carbonate of lime, of a pure white color. With the mixture of sumac extract and carbonate of soda, the iron was colored with a black film, and the solution was much discolored. It appears, therefore, to M. Vignon, that the following deductions are permissible for these experiments: (1) free tannin matters attack boiler iron; (2) excess of sodium carbonate does not prevent this objectionable action; (3) sodium carbonate has no injurious action on boiler-plates. Hence, the use of tannin as an anti-incrustator is injurious to iron boiler-plates, in his opinion, on account of its corrosive action.

A writer in a recent issue of the *Chemische Zeitung*, namely, Herr L. Manstetten, attacks this view; and while he does not advocate tannin for use in boilers, he gives reason for believing that it has little tendency to attack iron after the first contact, the metal becoming coated and protected from further action. He deduces this theory from his experiments with iron as a material for vessels used in the extraction of coloring matters, which shows that the quantity of iron taken into solution is inconsiderable, and that, although the first few batches of liquor are discolored, and have to be filtered through spent tan, subsequent extracts are unaffected. Further direct experiments, consisting in boiling slips of iron boiler-plate in tannin solutions for various periods of time, show that the rate of attack is exceedingly slow. Manstetten concludes that the risk of injury to the boiler from the use of tannin as an anti-incrustating agent, has been much exaggerated.

It is evident that when two men, both possessing considerable scientific attainments, differ in this deliberate way, there is room for further research in this direction. The question of the best anti-incrustator is of such importance to all industries in which steam is employed, that there is every inducement for it to be taken up and systematically studied.

Elsewhere in this issue we publish an editorial from the New York *Sun* on recent progress in surgery. Toward the close of this article the following sentence will be found: "It is doubtful if much more can be done to perfect surgery as a science." That reminds us of a similar remark we met with, not long ago, in a little "catechism of electricity" published in 1820. At that time not one of the great inventions or principles that we at once think of when the word electricity is mentioned had been discovered (with the exception, perhaps, of the electric light, which Davy had previously produced, at great expense, with a primary battery). Yet the author of the little book spoke with considerable earnestness of the limitations of his subject, and said that in all probability the philosophers of his day knew about all there was to be known about it. Doubtless, he said, some minor discoveries would be made, but the general principles and laws of the subject were pretty well understood. And yet Faraday, Henry, Thomson, Maxwell, Hertz, Lodge, and Fitzgerald were still to come, before we could arrive at our present state of knowledge. We are more modest now, and the general feeling is that we are only at the threshold.

Modern Surgery.

The practice of surgery has always been more or less of a science. Even in the earliest times very serious surgical operations were undertaken with success, and some of them are now often wrongly proclaimed as modern in their origin. Ovariotomy was practised by the ancient Hindoos. An example of prehistoric trephining may be seen in a skull from Peru at the Museum of Natural History in this city.

The morbid conditions which the surgeon has to combat are tangible and objective. so that his chief difficulties have been in the way of skillful manipulation of instruments, the management of blood vessels, and the proper cleansing of wounds. But there are striking features in the surgical science of the past fifty years which mark epochs in its advance, and of which the surgeons of other centuries could scarcely have dreamed.

The first of these was the introduction of anæsthesia from chloroform and ether, making it possible for patients to undergo operations the very pain of which might under former conditions have caused their death. This has enabled the surgeon to prolong his procedure for hours if necessary, instead of limiting himself to the seconds and minutes which must have seemed an age to the tortured and conscious sufferer. We are now so accustomed to hear of the use of anæsthetics in all operations that it hardly seems conceivable that so few years have elapsed since they were first employed.

Another revolution was accomplished by a discovery which has affected both surgery and medicine alike, and that is the parasitic origin of diseases. When it was learned that air and dust and water were everywhere filled with countless millions of invisible germs, and that some species of these, by being inhaled or swallowed, entered and poisoned the blood, producing contagious and infectious fevers; that some were the cause of fermentation, and that putrefaction was absolutely impossible without their presence, it did not take long for the surgeon to investigate their relation to the wounds which he was obliged to make, and through which these bacteria might readily find entrance into the system. Never before had he understood why erysipelas sometimes appeared in a wound; why blood poisoning would follow some of his operations; why some of his wounds would heal at once by first intention, while others would suppurate for weeks or show no tendency to heal; why tetanus or lockjaw was to be expected as an occasional complication; why hospital gangrene would haunt his wards like a dread phantom that could not be dislodged. How many thousands of lives have been sacrificed through such ignorance? One need but to glance through some medical history, such as that of the War of the Rebellion, to learn what havoc and devastation these invisible and unknown enemies made. Sabres, bullets, and cannon balls were trifles compared with them. More than three times as many fell victims to these impalpable foes during the war as were killed in battle. Fully one-sixth as many as were slain on the field died from surgical germ diseases alone, from the infection of their wounds by the myriads of the air.

Now, the surgeon knows that no atmosphere, whether that of mountains or sea, is absolutely free from putrefactive germs, and that the air of hospital wards and sick rooms is particularly loaded with organic matter of all kinds, and with microbes in abundance. From these well-established facts has arisen what is known as the antiseptic treatment of wounds. Substances have been found which kill these germs, among the first and best of them carbolic acid; and now we have numberless germ-destroying agents. The modern surgeon gets rid of every microbe upon the surface of the part before operating, by shaving and thoroughly washing the skin with antiseptic solutions; every instrument, sponge, suture, and ligature is treated or saturated with them; his own hands and those of his assistants must go through a similar process of disinfection; the operating room is made as germ-proof as possible by causing each nook, corner, and wall to be of such material and shape that they may be scrubbed down frequently with bactericides; often a spray of antiseptic vapor is played into the air above the wound during the operation; the towels, bandages, and dressings of cotton, lint, and gauze are all made similarly safe. Should he meet with the old and too familiar symptoms, the surgeon knows there must have been some flaw in the preparations. The bacteria still occasionally outwit him; but the contrast between the results of to-day and those of yesterday is marvelous. Antiseptic surgery is of such recent origin, however, that there are still many surgeons, generally older men and in the provincial districts, who either have no knowledge of the scientific facts, or who, bound fast by hereditary prejudices, profess to disbelieve in their truth, and continue to immolate fresh victims year after year upon the altar of their own ignorance.

As regards operative procedures themselves, anæsthetics, antiseptics, improved methods of checking hemorrhage, and a variety of new instruments have made it possible, not only to undertake new operations and perfect old ones, but also to practice conservatism in surgery. Thus amputations are by no means so common as formerly, for limbs are preserved by different operative methods under these new conditions which before it was considered impossible to save.

If there is anything, however, which serves to distinguish the surgery of this time from that of the past, it is its visceral character. Then the operator busied himself chiefly with externals: outer tumors, the skin, limbs, and the like. Now his most brilliant work is among the organs contained in the cavities of the abdomen, chest, and head. No organ is beyond the reach of his knife. Pelvic organs are extirpated; large abdominal tumors, and such organs as the spleen, the kidney, and the larynx, are often successfully removed. Injuries to the intestines and the stomach are no longer considered as necessarily fatal, for they may be sewed up, parts cut out and the ends approximated, very much like rubber hose. They are beginning to cut tubercles out of the lungs, and tumors are removed from regions in most dangerous proximity to the heart, the large blood vessels, and the great nerves. But most remarkable of all is the very recently developed surgery of the brain and spinal cord. This new departure is wholly owing to the wonderful advance made in the knowledge of the anatomy and physiology of the central nervous system. The surgeon depends upon the nerve specialist to localize the morbid process in the brain or spinal cord, and to determine the nature of the disorder, whether hemorrhage, tumor, abscess, or whatever it may be. It is a dangerous region, but the results are sufficiently successful to warrant operations where death is imminent without them. Quite lately operations have been carried out upon the brain itself in peculiar forms of insanity, and in cases of idiocy where the growth of the brain seems to be hampered by too early union of the bones of the skull. In the latter case the design is to remove sufficient bone to allow the brain to grow. As in every novel project or enterprise, time is necessary before judgment can be passed upon the experiment, so in these operations for insanity and idiocy their actual value cannot be determined for at least ten years from their performance.

It is doubtful if much more can be done to perfect surgery as a science. Methods and technique may be improved, but there seems to be little territory left to explore. There is one direction, perhaps, in which further achievement is possible. As is well known, the surgeon usually takes away what is diseased or defective. The progress should be in the way of substitution. The transplantation of skin, hair, bone, and teeth, and the transfer of blood from one to another have been accomplished. We must now demand of him new eyes, new limbs, new internal organs, new hearts, and new brains in the place of those which have become so disordered as to require his supervision and manipulation. — *New York Sun.*

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES—VOL. XIII. HARTFORD, CONN., MARCH, 1891. No. 3.

A New External Furnace.

The disposition or consumption of waste in tanneries, saw-mills, pulp-mills, etc., has been an important problem with manufacturers in these kinds of business for some years. In earlier years water power was used in such mills almost entirely, and there was no satisfactory way of getting rid of the refuse. Tan bark was used for making

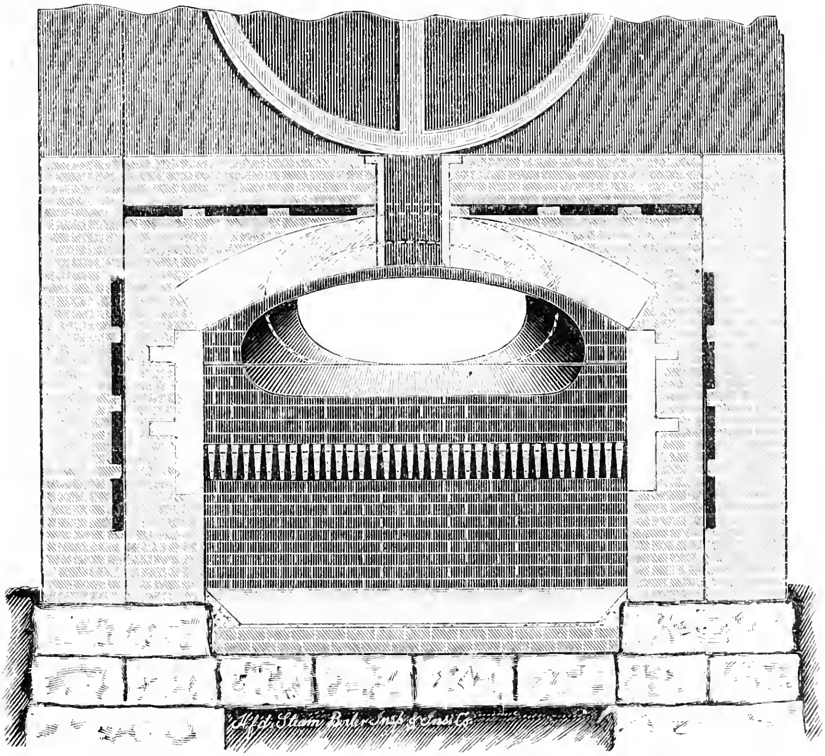


FIG. 1.—FRONT VIEW OF FURNACE.

roads and walks, and saw-dust was thrown into the rivers on which the mills were located.

When it was found that the fish industry and other interests were seriously injured by this practice, legislation was sought, which would forbid the waters being polluted in that way. Then large furnaces were constructed at a safe distance from the mills, where all such refuse as edgings and sawdust was consumed. These furnaces are still used in some sections of the country. But other manufacturers, who looked carefully into the question of economy, concluded that this waste could be utilized and used as fuel under steam boilers, and as steam power became more generally used, the burning of the waste under the boilers was adopted.

Various methods for conveniently handling this fuel have been devised, and various kinds of furnaces have been proposed. The extension furnace has found favor in tanneries, saw-mills, and pulp-mills, though different principles have been introduced in its construction. The differences are largely in the design of what corresponds to the bridge wall in ordinary settings at the rear end of the furnace. This sometimes has one large opening, and sometimes two or more smaller openings. In the usual forms

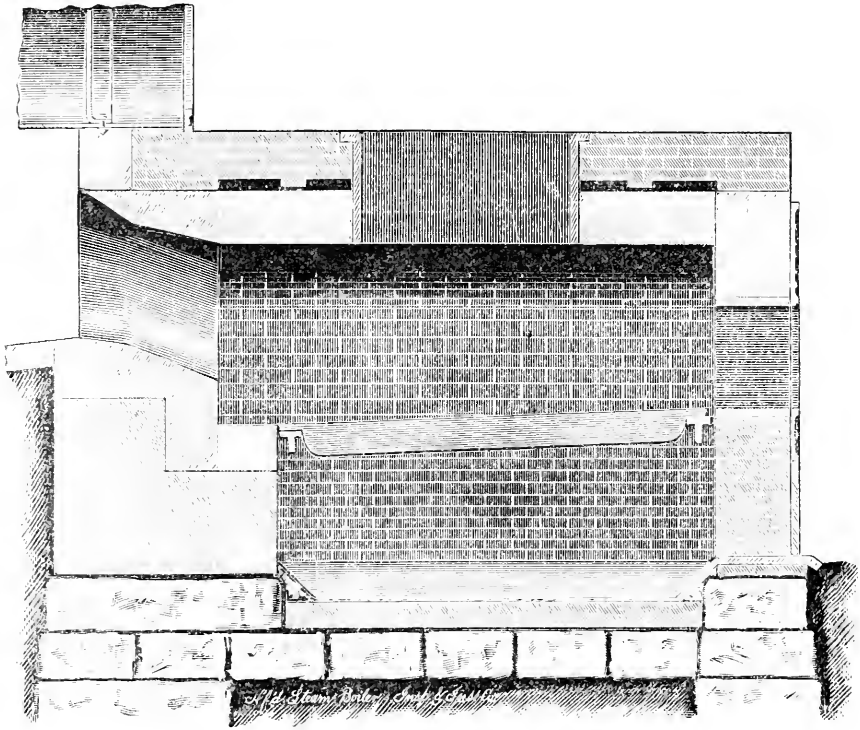


Fig. 2 — Side View of Furnace.

with one opening, the escaping gases flow from the furnace directly through the opening, mingling but little with one another as they rise from the incandescent fuel, and passing directly to the fire surfaces of the boiler. Where two or more openings are used, the temperature has been found by experiment to be more or less unequal under the boiler, back of the bridge wall.

In order to overcome such difficulties as have been noticed, the furnace here illustrated was designed. Fig. 1 is a view from the front looking into the furnace. Fig. 2 is a longitudinal section through the furnace, and Fig. 3 is a top view or plan of it. The opening in the rear wall of the furnace, it will be noticed, is contracted both horizontally and vertically, at about the middle, flaring towards the furnace and also toward the exit. This construction is seen clearly in the illustrations.

The general shape of the opening corresponds to what is known in physics and mechanics as the *vena contracta*. The gases escaping from the furnace flow without interruption into the flared opening, and if there are currents of different temperature, owing to the admission of an excess of cold air through the feeding doors of the furnace, or otherwise, they are brought together at the contraction, and are brought to as nearly uniform a temperature as possible. After emerging from the *vena contracta* (which in this construction is in the bridge wall itself) the gases are uniformly distributed to the heating surfaces of the boiler, and not concentrated on any particular point, as is the case with some other constructions.

In Figs. 2 and 3 it will be noticed that the grate bars do not extend entirely back to the bridge wall, but only as far as a flat ledge or hearth of fire brick, about a foot

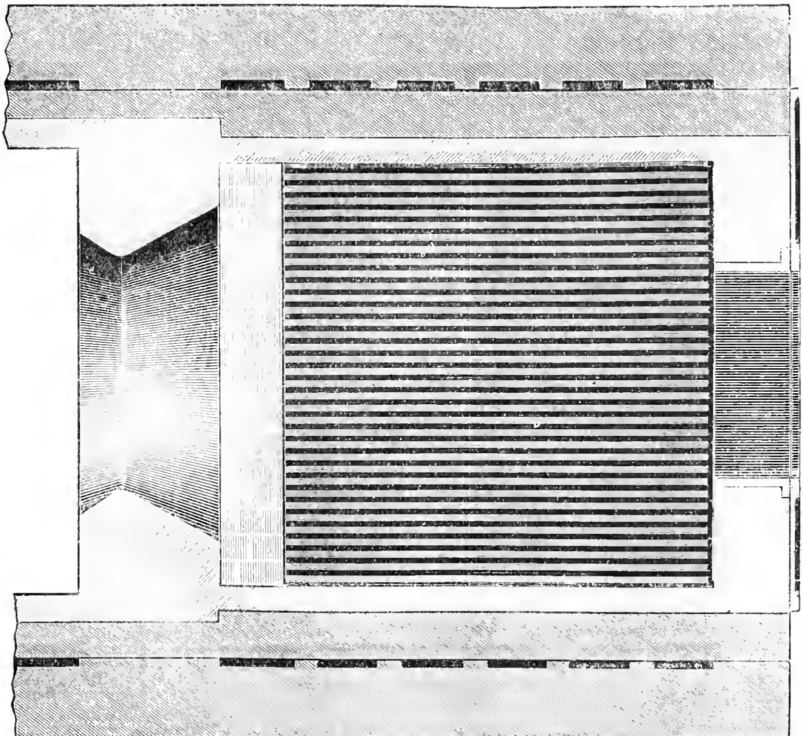


FIG. 3. — TOP VIEW OF FURNACE.

wide. In feeding the furnace it will not always be possible to cover the entire floor with fuel, and a space a few inches wide may sometimes be left bare at the back end. If the grates extended entirely back to the bridge wall this would leave an open space at the back through which cold air would pour up from the ash-pit, chilling the gases from the burning fuel unnecessarily, and lowering the efficiency of the furnace. The hearth prevents this, and its action, we think, will be fully understood without further explanation.

This furnace has been patented by Mr. J. M. Allen, of Hartford, Connecticut. He has assigned the patent to the Hartford Steam Boiler Inspection and Insurance Company. It will not be put on the market for sale, but will be used only in connection with the company's regular business, and for the benefit of its patrons. Mr. Allen has other valuable inventions which will be used in connection with these furnaces, and which will be described and illustrated at a future date.

Boiler Explosions.

JANUARY, 1891.

TOW BOAT (1). The tow boat *Annie Roberts* exploded her boilers at Portsmouth, Ohio, on January 25th, killing two men and fatally injuring three others. All the victims were Pittsburghers. The boat belonged to Horner & Roberts, coal operators of this city, and was valued at $20,000.

GRAIN ELEVATOR (2). The boiler in E. G. Vernon's elevator in Anderson, Ind., exploded on January 2d, at 4 o'clock, completely wrecking the building, and also badly damaging a saloon four hundred feet away. No one was injured.

DRILLING WELL (3). The boiler at the Breene drilling well in Westview, near Pittsburgh, Pa., exploded, January 2d, with terrific force; but fortunately no one was injured. The tool dresser had just left the boiler and was entering the derrick, where the driller was at work, when the explosion occurred. The boiler was an old one and had been in use for some time, and high pressure is assigned as the cause of the explosion.

LOCOMOTIVE (4). On January 6th a locomotive exploded on the Newport News & Mississippi Valley road, near Salt Lick, a small coaling station between Morehead and Mt. Sterling, and about sixty miles west of Cattletsburg, Ky. At the time of the accident the train was running at the rate of about twenty-five miles an hour, the engineer having slowed up for the station. Engineer Hiltbruner was thrown fifty yards, and killed instantly. The fireman, Keelen, was scalded to death. The entire train left the track and rolled down an embankment several feet in height, and, strange to say, but few passengers were injured. Several received slight cuts from broken glass.

LOCOMOTIVE (5). A freight train was derailed on the Richmond & Danville road near Gaffney, N. C., on January 7th, and the boiler of the locomotive exploded. The engineer, fireman, and two brakemen were killed, and three other trainmen seriously injured.

HEATING BOILER (6). On January 9th the boiler of the heating apparatus in the basement of the three-story Halsey block just opposite the Huntsville Hotel, Huntsville, Ala., exploded, and part of it was blown through the floor. The floor was torn up and the front doors and plate window glass of one store-room blown out. This room was occupied by A. Maxville, a tailor, who was thrown out on the pavement in front and fell into the basement, the front part of the pavement having also been blown off. Maxville was badly hurt. The damage to his stock of goods is estimated at $250. The damage to the building is supposed to be in the neighborhood of $3,000.

SAW-MILL (7). A terrific boiler explosion occurred at Coopridor's saw-mill, a mile west of Middlebury, near Brazil, Ind., on January 11th. While the boiler was literally torn to pieces, the fragments projected in every direction, and the engine thrown out of position and wrecked, and, though five men and a team of horses were immediately in and about the mill, all escaped without a scratch. One piece of the boiler struck within a few feet of three men who, standing by the saw, had just turned a log on the carriage. The engineer, a few minutes before the explosion, had left his position and was passing back when the explosion took place.

Silk Mill (8). A large steel boiler in the American Silk Dyeing and Finishing Company's Works, at Hawthorne, near Paterson, N. J., exploded on January 12th. The building was badly damaged, as was also the machinery. There were twelve people at work in the color room at the time of the explosion. All escaped injury except George Hutchinson, a lad who was assisting his father, the boss color mixer. Young Hutchinson was scalded by the escaping steam, and bruised by being thrown down by the force of explosion. He was not badly injured.

Plush Factory (9). A steam pipe burst while John Murdock was repairing the boiler of the Tingue Plush Factory at Seymour, Conn., on January 11th, burning Murdock so badly that he died a few hours later.

Locomotive (10). A locomotive at Gordon, on the Reading Railroad, exploded on January 13th. Engineer Martin Saeger was hurled 300 feet in the air and landed in a large pond. Brakemen John Smith, Irwin Bolich, and Nicholas Hump were struck by flying debris and horribly injured. Smith and Bolich were killed and Hump was fatally hurt. The engine and neighboring buildings were entirely demolished. A large piece of the boiler almost killed an entire family.

Saw-Mill (11). The boiler of a steam saw-mill in operation at Town Gate, near Norfolk, Va., exploded with terriffic effect shortly after noon on January 14th. A white boy and a negro man were instantly killed, and the mill considerably damaged, by the explosion.

Saw-Mill (12). A bad accident occurred at Mr. J. R. Merritt's steam mill at Cade's, about nine miles from Scranton, S. C., on January 9th. The engineer at the mill fired up the boiler, but the safety-valve got out of order, and the result was that the boiler burst with terrific force, instantly killing Bernard Devine, one of the mill hands.

Licorice Works (13). John Fleet, aged 30 years, Michael Kinsley, aged 29, and Michael Devine, aged 30, were frightfully scalded, on January 17th, by a boiler explosion at Andrews & Forbes's licorice factory on the canal above Bloomfield avenue, Newark, N. J. They were removing the head of a compressor attached to the boiler. The head was blown out, and the escaping steam scalded the men frightfully. They were taken to St. Michael's Hospital, where their wounds were dressed. The property loss was about $2,500.

Electric Lighting Station (14). On January 19th a large boiler burst in the electric light company's station in Akron, Ohio. Little damage was done, but the city was in darkness for some time.

Distillery (15). Five men were badly scalded at 9 o'clock a.m., on January 19th, by the explosion of the boiler at Walsh's distillery, Paris, Ky. The machinery and building were badly damaged. No lives were lost.

Fire Engine (16). On January 24th a train on the Pennsylvania Railroad collided with a steam fire engine at the Barrow street crossing, Jersey City. The boiler of the fire engine burst, and Daniel Diman, the driver, was instantly killed.

Rotary Boiler (17). A large straw bleach blew up in Rock Falls, Ill., on January 27th, killing John Myers and severely injuring George Zimmer, John Fidas, and Henry Page. The money loss was $10,000.

Saw-Mill (18). A very distressing accident occurred eight miles north of Overton, Tex., on January 28th, at the saw-mill of Peter Henry. The boiler blew up, killing Bill Henry and Dan Tucker, colored, instantly, and fatally wounding John Austin, also colored, and seriously, but not fatally, wounding Rev. Tully Choice. This is the second accident of this nature that has occurred near here in the last twelve months, each time attended with loss of life.

Hotel Boiler (19). A panic was created on January 28th by the bursting of a huge boiler under the Hotel Imperial at Thirty-second street and Broadway, New York. Smoke and steam filled the hotel, and the guests, believing that fire had attacked the new hotel, fled to the street. Policeman Gallagher, who was on the opposite corner, saw the smoke and turned in an alarm, and No. 1 Engine responded to the call. The firemen forced their way into the cellar of the hotel, where they discovered the cause of the outbreak. The steam was turned off, and boiler-makers sent for to repair the damage.

Saw-Mill (20). The saw and shingle mill of R. C. Herbison, located at Meredith, Clare County, fifty miles west of Saginaw, Mich., was completely wrecked by an explosion of the boiler on January 28th. George Badder, a sawyer, and Albert Finch, the fireman, were torn to pieces, and Mr. Herbison, George Hone, and Walter Bennett were seriously injured. Other employes were slightly hurt.

Stock Yards (21). The boiler in the Argenta Stock Yards, Little Rock, Ark., exploded on January 28th. But little damage was done to anything except the boiler and room. No one was hurt.

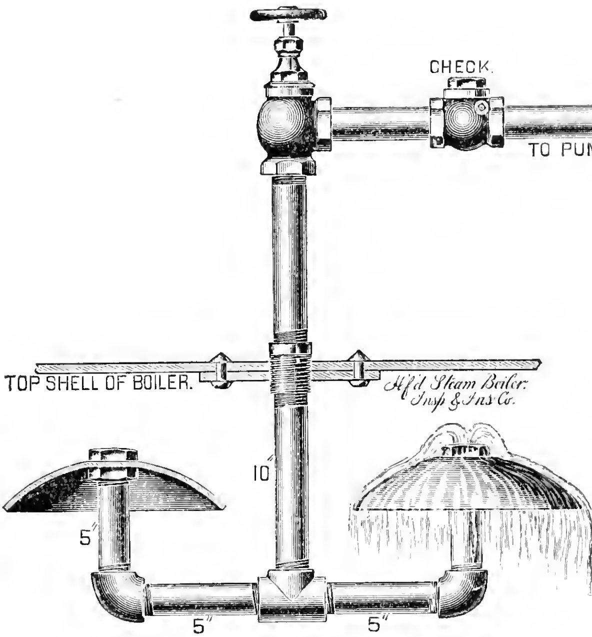
Top Feed in Boilers.

In the eastern part of this country, where the water is usually pretty good, the arrangement of feed that we show in all the plans and specifications sent out from this office works well and gives perfect satisfaction. As most of our readers well know, we recommend that the feed-pipe shall enter the front head just above the tubes on one side of the boiler, passing down the entire length of the boiler, crossing over to the other side near the back head, then turning downward and discharging between the tubes and the shell. By putting in the feed-pipe in this way the water becomes pretty well heated before being discharged into the boiler, and the danger of sudden contraction of plates is greatly lessened.

In the West, where the water is often poor, other devices are sometimes preferred to this. One of these is described in the following article, which comes from Mr. C. A. Burwell, Chief Inspector in our Northern Ohio department. He has found it to work well in his locality, and no doubt it could be used with advantage in other places where similar conditions prevail. How far it differs from other arrangements having the same objects in view, we are not prepared to say.

"Probably few engineers or owners of steam-boilers appreciate the effect that the introduction of feed-water has upon a boiler, so far as its life is concerned. If it could be introduced in a steady stream, and at a uniform temperature all the time the boiler is in operation, the location of the point of introduction would be of little importance, particularly if the water was free from scale-forming substances. Such favorable conditions, however, are rarely met with. Most boilers are fed intermittently, the feed varying in temperature between, say, 60 degrees and 200 degrees. In every case its temperature is lower than that of the boiler, and if care is not taken it will chill the shell and start leaks or cracks, if it does nothing worse. Then, too, the deposit of scale cannot be controlled to any great extent. The present article is designed to show how all expansion and contraction of shell-plates may be avoided, and deposit of scale largely prevented. These can be accomplished, in the writer's experience, by spraying the feed into the steam space of the boiler. Experience has shown that this can be done without noticeably increasing the moisture in the steam passing over to the engine.

"A simple device for accomplishing this is shown in the accompanying cut. It is



TOP FEED APPARATUS.

made of pipe of the same size as the feed line. The spray plates are 10 inches in diameter, made of iron (16 gauge being a good thickness), and hammered into convex shape. The short upright pipes shown in the cut pass through them, and to these the plates are secured by lock nuts above and below. The water bubbles up to the top of the plates, and runs off as it would from an umbrella. The trap form of the arrangement prevents steam from entering the feed line and causing snapping or pounding noises from condensation. There are two free openings, each of which is the full size of the main feed pipe.

"By spraying it into the steam space in this way, the water becomes thoroughly heated before mingling with that in the boiler below, and, as it is in small particles, it is carried along in the general circulation, and does not come in contact with the shell in such a way as to cause contraction. Furthermore, the scale-forming material is precipitated in a finely pulverulent form *in the water*, and not on the tubes or plates, so that instead of adhering to the boiler it remains in suspension, and is readily gotten rid of when the boiler is emptied for cleaning. My experience shows that boilers can often be kept clean by this method of feeding, when the scale was very troublesome with the ordinary arrangement.

"When the water is very bad some scale will be deposited, though the amount will be much less than with any other method of feeding, and the location of the deposit can be pretty well controlled. It will form close to the feed pipe discharge.

"We have next to consider the best place to put the delivery. No absolute rule can be given for this, but, generally speaking, it should be as near the front head as practicable, in tubular boilers; for the deposit, if it forms, will then be least likely to injure the tubes or cause leakage. In long flue and plain cylinder boilers the rear end is preferable, for in these types the shell is most likely to receive the deposit, and the rear end is the coolest portion of the shell. In any case the spray feed should be as far from the main steam opening as possible, in order that the strong current of steam passing out may not catch the particles of water and carry them over into the engine.

"In some sections of the country the top feed is used very generally, and in all cases it gives satisfactory results when properly put in."

Must the Wave Theory Go?

An esteemed friend has sent us some copies of *The Microcosm*, a monthly journal published in New York by Dr. A. Wilford Hall. We have been requested to examine certain articles contained in it, relating to the usually-accepted theory of sound, and have been invited to express our opinion of them.

The articles are rather belligerent in tone, and it is not easy to infer from them just what Dr. Hall's theory of sound is. We find a short paragraph concerning his "substantial" philosophy, however, which reads as follows: "Substantialism teaches that every force of nature, or phenomena-producing cause, whether in the physical, organic, conscious, or spiritual realms, — such as heat, electricity, magnetism, gravitation, light, sound, cohesion, life, instinct, mind, soul, or spirit, — instead of being a mode of motion, is a substantial, though immaterial, entity, and as really objective as are any of the material objects around us. On this broad and original foundation the Substantial Philosophy has taken its stand, and challenges the education of the philosophical and scientific world."

We do not get clear enough notion of his sound theory to explain it in detail, but we may perhaps be allowed to urge a general objection to it that will apply, no matter what its precise form may be. It is easy enough to assume a new medium, or an immaterial and elusive vapor, to account for each new class of phenomena, for since we don't know anything about it and can't examine it, we may make all the assumptions we please in regard to it, and thus make it conform to the most varied requirements. Any one of intelligence and ingenuity can do that. But before we can command attention and show that our theories are not only possible, but also plausible and probable, *we must predict something hitherto unknown, and then show by experiment that this thing is a fact in nature.* Newton's law of gravitation was not worthy of any very considerable attention until he had shown that the force of gravity at the moon's distance is just sufficient to keep the moon in her orbit. Even then it could not be regarded as more than plausible. But when he had applied it in a mathematical investigation of the moon's motions, and found that his theory required that certain irregularities in this motion should exist, and when, subsequently, it was found, by actual observation, that these irregularities *do* exist, the theory of universal gravitation was accepted as a fact. So, also, with Maxwell's electro-magnetic theory of light. Any child could assume that the medium that transmits light through space is identical with the one that transmits electricity and magnetism; but this assertion, based on nothing but a personal opinion, would be worth nothing. When Maxwell applied his elegant and powerful analysis to the question, however, and proved that if the two media were identical, the ratio of the electrostatic to the electro-magnetic units must be equal to the velocity of light, and when subsequent experiments showed this to be the fact, his theory was at once accepted. Now what has Dr. Hall predicted and afterwards verified, that should make us have confidence in his theory?

It is true that he devotes many pages to an attempt to show that the accepted law of decrease in sound intensity as the distance from the source increases, is an absurdity. How far his reasoning is accepted by his own followers may be inferred from his own statement: "Some of our supposed former best friends have turned angrily against us and have dropped *The Microcosm*, even refusing to correspond with us in a friendly manner." Even the doctor himself finally becomes convinced that he was in error. "We are no little vexed," he says, "in being compelled to say that Prof. Alonzo Hall has succeeded in convincing us, notwithstanding our confident belief to the contrary, that our article on 'squared distance inverse' contains serious mathematical errors. The details of these errors," he adds, "would be unintelligible to a majority of our readers, and would be uninteresting, as well. Suffice it to say, it is the professor's opinion, expressed as kindly as possible so as not to ruffle our equanimity, that mathematics is not our 'best hold,' and we are half inclined to concede to him the honor of having convinced us of this fact." Now we wonder if Dr. Hall ever read Sir John Herschel's *Outlines of Astronomy*. If so, perhaps he noticed the memorable passage where Sir John refers to the necessity of a mathematical education. Speaking more particularly of astronomy (though his words are equally applicable to physics in general) he says that "admission to its sanctuary, and to the privileges and feelings of a votary, is only to be gained by one means, — *sound and sufficient knowledge of mathematics, the great instrument of all exact inquiry, without which no man can ever make such advances in any of the higher departments of science as can entitle him to form an independent opinion on any subject of discussion within their range.*" The italics are Herschel's own, and his statement is especially applicable to the wave theory of sound; for to understand this thoroughly, and appreciate the force of its arguments, one needs to use the infinitesimal calculus, theoretical mechanics, and differential equations as freely as he would his *A B C's*. It is folly to combat the wave theory of sound without fully knowing what it is, and we should recommend Dr. Hall, after he has made himself familiar with sufficient mathematics, to read the first three chapters of Daniell's *Principles of Physics*, and then take up the great works of Rayleigh and Donkin. He will find that all his difficulties have occurred to others also, and that they have been answered in a masterly and satisfying way.

In conclusion, let us say that while Dr. Hall is a vigorous writer, and a fearless and confident controversialist, we hardly think that physics is the proper sphere for his activities. Just read the following, for instance, and see what a mistake he made when he didn't go into political journalism in the West: "Last month we incidentally referred to one Briggs, M.D., who had become howling mad because the sensible people of this State persisted in sending four dollars for our priceless health pamphlet, and could not be cajoled by him into subscribing, at half the price, for his own crotchety, half-starved and dyspeptic burlesque on medical journalism. This poor disgruntled and moribund vender of poisons is now so raving at our gentle suggestion of last month, that 'somebody ought to give him a Brown-Séquard injection under the fifth rib,' that he makes faces and fills one mortal column with his stereotyped wail of 'humbug,' 'humbug,' 'humbug,' closing with the following bilious shriek." . . . . [*Microcosm*, Jan., 1890]. There is virility for you, and choice diction. What a pity he did not follow coyote journalism, instead of stooping to the architecture of theories!

The Locomotive.

HARTFORD, MARCH 15, 1891.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

THE LOCOMOTIVE *can be obtained free by calling at any of the company's agencies.*

Subscription price 50 cents per year when mailed from this office.

Bound volumes one dollar each. (Any volume can be supplied.)

Papers that borrow cuts from us will do us a favor if they will plainly mark them in returning, so that we may give proper credit on our books.

ON one or two occasions we have given the address of Mannesmann Bros., as *Manheim*, Germany. It should be *Remscheid*, Germany.

The report for 1890 of the *Sächsischer Dampfkessel-Revisions-Verein* (Chemnitz) is at hand. We notice in it, particularly, the remarks relating to the steam engine and the indicator.

The Industries and Wealth of Cleveland is a paper-covered volume of 160 pages, containing a review of Cleveland as a whole, and a minute account of its present industries.

Connecticut of To-day is a similar volume describing the chief business centers of the State. Much interesting information is given in this publication, and some of the cuts illustrating it are very good.

The Epitome of the World's Patent Laws, issued by the British and European Patent Agency of New York, is unusually extensive for a publication of its kind. It gives, briefly, the laws regulating the issue of patents in the different countries, and also the area of the country, its population, its revenue, its imports and exports, its railway mileage, and its chief productions and industries. Even Natal, Congo, Liberia, and Fiji are included.

WE have received from Mr. Chas. J. H. Woodbury, Vice-President of the Boston Manufacturers' Mutual Fire Insurance Co., a copy of the interesting lecture on *Conflagrations in Cities* that he delivered before the Franklin Institute in January last, and which is now republished in pamphlet form. Mr. Woodbury reviews many of the great fires of antiquity, and speaks more fully of the more modern ones in our own country. He also explains the inspections that fire companies make, and discusses fire-resisting construction, and apparatus for extinguishing fires.

We also wish to acknowledge, from the same gentleman, a report of 219 fires that occurred in 1890, and the annual report of the company he represents, for 1890.

We have received from Messrs. John Wiley & Sons of New York a copy of Prof. Jay M. Whitham's *Constructive Steam-Engineering*. We can give the best idea of the book, perhaps, by quoting from the preface. "The aim has been to treat the constructive features exhaustively, yet necessarily leaving out a consideration of the many peculiarities of the various manufacturers, and to produce a work of value to the designer, draughtsman, student, working engineer, fireman, and mechanic. First, a brief classification of the various types of engines is given, after which follows a chapter on heat and steam, embracing thermometers and calorimeters. Next, the constructive details of an engine are illustrated and discussed, after which the indicator and its uses are presented. Then there is a chapter from the author's treatise on *Steam-Engine Design*, treating of the use, operation, and settings of the slide valve and independent cut-offs, using Zenner's diagrams for illustrations. Next follows a discussion of the various forms of valve-gears and automatic cut-off and throttling engines. A chapter is now devoted to compound, triple-expansion, and quadruple-expansion engines, after which condensers, pumps, and pumping-engines are considered. Then comes a chapter on the miscellaneous attachments and minor details of an engine, embracing stop, throttle, and relief valves, stuffing-boxes, belting, lubricators, etc. Next is given a chapter on the management of engines and pumps, engine trials and dynamometers. We now come to boilers, discussing in one chapter the theory of combustion and the various types in use, after which their constructive details and strength are treated in another chapter. The last chapter relates to the appendages and accessories of boilers, and to their decay and management." The book is well illustrated, and contains about 900 pages.

The Strength of Aluminium.

In view of the extensive uses to which aluminium is now being put, both by itself and when alloyed with other metals, the following figures, which we take from the *Practical Engineer*, will be of interest. They were given by Messrs. E. Hunt, J. C. Langley, and C. M. Hall, before a recent meeting of the American Institute of Mining Engineers.

A bar of the metal, one inch square and twenty-four inches long between supports, was loaded at the center and the deflections observed, with these results:

With load of 50 pounds deflection was $\frac{3}{64}$ in., and permanent set $\frac{2}{64}$ in.
" " " 150 " " " $\frac{23}{64}$ " " " " $\frac{13}{64}$ "
" " " 200 " " " $\frac{47}{64}$ " " " " $\frac{40}{64}$ "
" " " 300 " " " $2\frac{13}{64}$ " " " " $2\frac{2}{64}$ "

The bar did not break, however.

Considering the *tensile strength* of aluminium *in relation to its weight*, the following table shows it to be not far from as strong as steel at 75,000 pounds ultimate strength:

Metal.	Weight of 1 cu. ft.	Tensile strength per sq. in.	Length of a bar that just supported its own weight.
Cast iron,	444 lbs.	16,500 lbs.	5,351 feet.
Ordinary bronze,	525 "	36,000 "	9,874 "
Wrought iron,	480 "	50,000 "	15,000 "
Hard struck steel,	490 "	78,000 "	22,922 "
Aluminium,	168 "	26,000 "	22,285 "

The aluminium used was from 97 to 99 per cent. pure, containing from one-tenth of one per cent. to one per cent. of graphitic silicon, and from 1.9 to 2.8 per cent. of combined silicon, as well as from $\frac{1}{25}$ to $\frac{1}{5}$ per cent. of iron.

The elastic limit per square inch in tension was found to be 6,500 lbs. for castings, 12,000 lbs. for sheet metal, 16,000 lbs. for wire, and 14,000 lbs. for bars. The ultimate strength per square inch in tension was 15,000 lbs. for castings, 24,000 lbs. for sheet metal, 30,000 lbs. for wire, and 26,000 lbs. for bars. The percentage of reduction in area was 15% in castings, 35% in sheet metal, 60% in wire, and 40% in bars.

Life at the Lick Observatory.

So many articles have been written on the scientific equipment of the Lick Observatory, and upon the discoveries the instruments are capable of making and are making, that I think, says a writer in the Boston *Journal*, a sort of description of the personal life of the observers on this mountain and the difficulties encountered will be of interest. The following description is taken from an address by the director of the observatory, Professor Edward S. Holden, before the Astronomical Society of the Pacific.

To those who visit Mount Hamilton in summer, says Professor Holden, nothing can seem easier or more delightful than to plan and execute investigations with the instruments at hand. A short visit there, however, would at once show the almost insurmountable difficulties that attend an attempt to live at such an elevation. As soon as winter sets in, storms that here in Massachusetts we would call cyclones sweep over the mountain, and drift the snow about the astronomers' dwellings more than ten feet deep. Three or four times during each of the winter months the wind blows at the rate of more than sixty miles per hour. Many of the stronger gusts, which must exceed seventy-five or eighty miles an hour, have never yet been measured, for no instrument can be found that will stand the test. Although the windmill which supplies the observatory with water is carefully furled before each storm and held in position by iron braces, nearly two inches in diameter, once a year it is torn from its mounting and destroyed.

During five days of February, 1890, absolutely no communication with the outside world was possible. The snow fell in enormous quantities, and a fierce blizzard was blowing, which could not be faced. On the sixth day of our imprisonment three men started together for Smith Creek and returned the same night, bringing the mail and thirty pounds of much-needed provisions, after a journey of fourteen miles, which had taken something like eight or nine hours of hard work.

In such a climate we should naturally expect to find whatever was necessary for warmth and comfort indoors. How different, however, is the account Professor Holden gives us.

There is nothing to be had nearer than San Jose, 26 miles away, and it is necessary to transport everything by stage. Frequently the stage has no room for our parcels, and very frequently has no passengers for the observatory, and stops at the foot of the mountain. In such a case we must send our men over the road 14 or 15 miles to Smith Creek. Very often the road has been impassable to wagons (on account of snow), and all our supplies have been brought in the mail bag on horseback. Whatever was too large or too heavy for the bag was not brought and had to be done without. During the 112 days from November 15th to March 8th the stage came to the observatory only thirty-six times. The difficulties in this matter can be met by a kind of "forehandedness," but when we come to the strictly scientific side of our difficulties, they are more serious. For example, a bit of colored glass is wanted to moderate the brightness of Mars, so that the satellites can be seen. Where is it to be found? There is not so much as a square millimeter of such glass west of the Alleghany Mountains. One of the prisms of our spectroscope is stained and yellow. It cannot be replaced nearer than Pittsburgh. If it is sent away, we lose its use for a month or more. The negatives of the solar eclipse of December 21 remained at the foot of the mountain from February 16 to March 5 from lack of some way to bring them up.

Fuel seems to be no exception to other articles in regard to the difficulty of getting it up the mountain. It is the present policy not to cut any wood on the reservation, and it must be found where best it may, and its delivery hastened as much as possible. During the winter of 1888 and 1889 the only wood available for the observatory and for the various households was from my private stores, which had been ordered in May, but which were not all delivered until the following February. The procrastination of our immediate neighbors has ceased to be annoying. It is majestic — colossal — like a great feature of nature. It must be reckoned with like the inexorable forces of heat, magnetism, and gravitation.

During the severe winter of 1886 and 1887 the Lick trustees were obliged to collect wood along the stage road, and it was delivered in small parcels like express packages. Even so it was impossible to keep the houses warm, and the water froze on the very dining-tables. The photographic lens of the great telescope was washed by Mr. Clark in water so cold that it froze where it was not immediately under his hands, and this because no room in the observatory could be heated above the freezing point.

The difficulty, aside from the scanty supply of fuel, rests with the chimneys, which were not properly constructed for the peculiar currents on the mountain top. The wind blows up the deep canons on either side and sweeps almost vertically down the flues. In consequence the flames are driven two or three feet out into the room. In vain every kind of chimney top has been tried. Nothing can remedy the difficulty but to rebuild the chimneys.

When summer comes there is constant communication between the observatory and the outside world, and the troubles of winter disappear. A new difficulty, however, now arises to tax the patience of the astronomers to the utmost — the water supply gives out. Two reservoirs on neighboring peaks are fed from springs by means of the windmill and a steam engine. A third just below the summit acts as a reserve in the summer droughts, and is filled with rain water. The frequent slight earthquakes that occur in California seriously injure the walls, so that a daily inspection has to be made, and the slightest leak stopped at once.

All these difficulties, of course, call for extra work on the part of the astronomers, for their regular routine duty that has been assigned them must be done every day. Each piece of extra work is written on a card and assigned to some person. When the work is accomplished the card is returned. During the last year 2,000 of these cards were made out, including about 3,000 to 4,000 items, or corresponding to 8,000 hours of extra labor. The secretary's letter-press copying book for the same period contains 51,000 pages of letters, which are equivalent to 500 working days. Also, during the last year 650 checks have been issued.

These figures give some idea of the life at the Lick Observatory. But we must not forget that the instruments are in use whenever it is possible, as the large number of observations in every periodical proves.— *Scientific American.*

On Having a Hobby.

Men incline to own up to the fact apologetically if they cherish some innocent pet habit, if they have a hobby far removed for their sterner interests and life-work. Yet having a hobby can be shown to be good and right, both by example and in the nature of things. Cato the Wise is a pleasant figure to us as, a simple farmer, he cultivates his ancestral farm; nor do we feel that he was less the fearless censor, the military genius, or the patron of literature by these lovable country tastes and pursuits. Old Izaak Walton is enshrined in our memories and hearts as one with whom piscatorial pleasures outweighed the desire for literary fame, and we like him all the better for it and feel that he was more of a man and a more charming writer therefor. In the present day it is refreshing to think of Englishmen like Blackmore, Americans like John Burroughs, who, while their fame rests on accomplishment in letters, do keep themselves braced and sweet by such occupations as gardening and fruit farming, so that their books are breezy and atmospheric and wholesome, like Nature herself. We knew a reputable old physician in New York city, who regularly at a certain hour of the afternoon appeared at an uptown hotel to play a game of billiards. For one hour he was completely absorbed in his caroms, and for that space of time patients might die and big fees go to brother leeches, — it was all one to him; he was a boy again, who had rather down his opponent than be President of the United States. No doubt this habit and hobby helped to preserve him in the green old age he was then enjoying. Again, we know a learned professor in one of our leading universities who has, at the top of his house, a carpenter's shop fitted up with a complete kit of tools and all sorts of sweet-smelling woods. And of a rainy afternoon you shall find him there, apron donned and perfectly happy, sawing, hammering, or filing to his heart's content — and to the joy of his wife, for he does all the mending of the home furniture. By doing this he is more of a boy and a better philologist at the same breath.

It is one of the head functions of the hobby to revive the child in us; to furnish an outlet for the fraction of animal spirits we have saved as flotsam from the wreck of the years. It is always a false and foolish feeling which induces us to give leash to such a hobby in secresy or with a semblance of shame, as if it were below the dignity of a serious person. Seriousness is all right and proper in its place, but it is a bore and a nuisance when out of place. "*Dolce est dissipere in loco,*" says Horace : it is a good thing to be a fool on occasion. Especially does it behoove Americans to have a hobby, for they are in danger from this exaggerated sense of seriousness, which, joined with the itch for gold, keeps their nose on grindstone and begets a belief in the silliness of a sportive moment. The continental peoples know better than this, and do better. They shut up shop and for an hour or two in the day go in for relaxation and enjoyment. We are in peril of permanently impairing the grand stock whence we sprung by this feverish insistence on all work and the formal suppression of the real John and the real Mary in us. Personality often comes out in a delightful and unlooked-for way in the pursuance of a hobby. Look at the English, for example, and see how men of middle life and elderly life play tennis and cricket, or ride or hunt, and how meagre are our resources, how sporadic the instances of the same sort of activity among us, though the movement is now in the right directron.

Another use of the hobby is its efficacy in checking the over-production of the genus *crank*. America runs the risk of turning out too many men who are specialists in the narrow sense, with limited culture or no culture, and who therefore incline to lay too great stress upon their particular pursuit. The utilitarian tendency in education is responsible for this. But that way insanity lies. "Sanity," says the wise man, "is a balancing of small insanities." The hobby steps in blessedly to furnish us balance, in a measure, at least, and has here a distinct and appreciable use.

Judged in its practical results, the hobby vindicates itself. We always prefer the man who has one, other things being equal. He proves more companionable, more likeable, has more sides and they are more attractive, he has a spring about him that is infectious and a rightness of head and heart that come of health of body and soul. His blood runs quicker and his eye is clearer; life is to him more worth the living and fuller of all sorts of interest. He has a better time of it himself and is of more use to his community, because he has kept on friendly terms with the play-day and the play-habit. Nor is it irrelevant or irreverent to say that he is, by reason of this, a more presentable creature to the God who made him and who gave birth to the hope that happiness and not stupid grind is the ultimatum of all existence.— *Hartford Courant.*

A CORRESPONDENT sends us the following clipping concerning the effects of heat upon steel, from the Los Angeles *Evening Express*. The subject is an interesting one, and we hope to say something further upon it shortly.

"Specimens of steel of three different qualities, depending on a varying proportion of carbon, have been tested in Germany to determine the change in their strength with change in temperature. Starting from 4 degrees below zero, Fahrenheit, the test-pieces diminished both in strength and percentage of elongation up to a temperature between 400 and 500 degrees, then rose to a maximum at about 600 degrees, and fell steadily beyond that point up to 1,100 degrees, the highest temperature tried. At 600 degrees, the strength of the weakest bar — supporting twenty-six tons at ordinary temperatures — was increased 34 per cent. ; that of the second bar — usually sustaining twenty-seven tons — had risen 27 per cent.; and that of the third bar — which would ordinarily sustain thirty-one tons — had gained 25 per cent."

The Early Days of Gas.

Beckmann, writing in 1786, said, "The lamps of London at present are all of crystal glass; each is furnished with three wicks; and they are affixed to posts placed at the distance of a certain number of paces from each other." But, long before this, inflammable coal gas had been known, although it took many years to bring it to the point of utilization. Towards the end of last century several people were found experimenting with this gas — Mr. Spedding, of Whitehaven, who lighted his office with it, and Mr. William Murdoch, who, in 1792, employed coal gas for illuminating his house and offices at Redruth; but is was reserved for Mr. Winsor to give the idea more permanent shape. Murdoch had what he considered weightier matters to attend to in connection with Boulton and Watt's famous steam-engine enterprise; Winsor, on the other hand, gave himself up almost solely to working out the one idea of street illumination by coal-gas.

There was a good deal of the dreamer about Winsor, and his inflated style of putting his scheme before the British public did not propitiate his audience. Still, much as he was ridiculed and abused, and much as he over-estimated the profit-yielding capacity of the new illuminant under commercial guidance, he did manage to force it into adoption, and to him belongs the credit of having been the first to light a London street with gas and the first to make gas-lighting a branch of commerce. In 1803 and 1804 he lighted the Lyceum Theatre with gas, and on a certain night in 1807 one side of Pall Mall was made to burst into luminous glory by means of this new flame. Winsor was completely carried away by his project, and wrote prospectuses and issued explanatory statements calculated to put to shame even the imaginative flights of the company-floaters of to-day. The joint-stock company which was formed to carry out Winsor's scheme was styled the National Light and Heat Company, and the profits to accrue, according to Winsor's own elaborate calculations, would yield "over two hundred and twenty-nine millions of pounds!" Giving over "nine tenths of that sum towards the redemption of the national debt, there would still remain a total profit of £570, to be paid to the subscribers, for every £5 of deposit!"

A patent was taken out by Winsor for the invention, and the company made an application to Parliament for liberty to proceed with the scheme, but were opposed by Boulton and Watt, and the bill was thrown out at the time, though a newly-constituted company that took over the old one was more successful in the following year. They had to wait a long time, however, for the coming in of Winsor's promised £229,000,000, for they were several years before they could pay any dividend at all, the opposition and prejudice being so strong. But Winsor had supreme confidence in himself and his projects from first to last. "All gas-lights," he wrote, "shown and exhibited before my illuminating the large theatre in the Lyceum, early in 1804, I fairly consider as so many *Will-o'-the-wisp* lights, known for centuries past"; after which he went on to set forth that while the methods of others had been to collect gas "in bladders in marshy ground," he had shown them the art of applying coal gas, of saving, analyzing, preserving, refining, and storing it; and he referred in the most contemptuous terms to the "theorists who could write but not practice," and "whose delicate hands and noses would have shrunk in horror from his numerous dirty and laborious experiments in kitchens and wash-houses, where his own laborers complained of being suffocated, and often refused to assist him, until he shamed them by the example of stripping, to perform what they thought was too dirty work for them." — *Romance of Invention.*

The Locomotive.

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Explosion of a Double-Decked Boiler.

Our illustrations this month show an explosion that occurred some time ago in a mill in Pennsylvania. The general situation of the boiler-house, mill, and other buildings will be seen in Fig. 2. The main building is about 165 feet long, and four stories high, the end of it being toward the street. On the street end was an L, about 18 feet square, containing a stairway; and in the corner between this L and the mill was the office, which was about 16 feet wide and 20 feet long, the entrance to it being on the

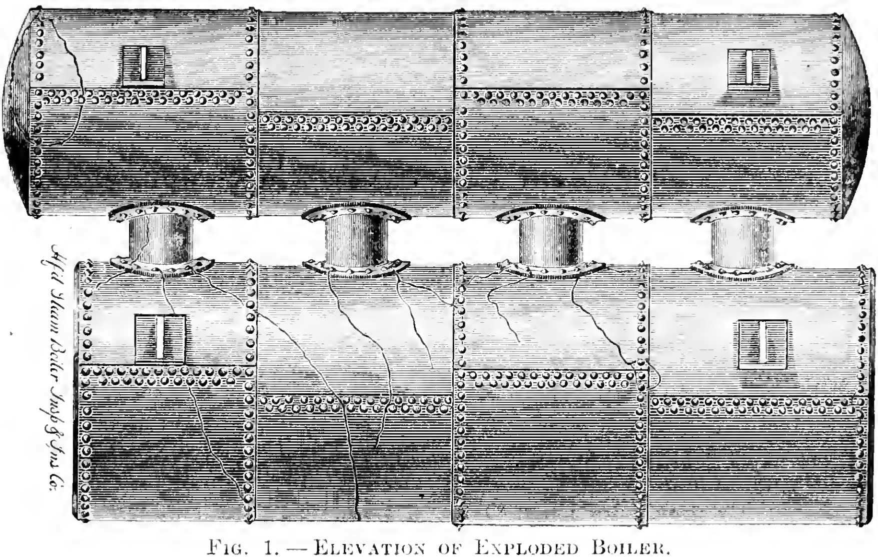

Fig. 1.—Elevation of Exploded Boiler.

second floor of the mill. The office is shown dotted in Fig. 2, as it did not extend down to the ground, but was supported by a column under its outer corner.

As will be seen from the cut, the boiler-house stood with one end against the mill, and about 35 feet from the rear end of it. The stack was built in the wall of the mill, between it and the boiler-house.

The general design of the boiler will be seen in Fig. 1, which also shows the manner in which the fractures ran, as nearly as we could judge from the fragments, which were scattered about the vicinity by the explosion. The dimensions of the boiler may be gathered from the following description of it: It was constructed of four sheets or rings, the top drum having the same number of rings, and being connected with the lower part by four necks, each 12 inches in diameter, one to each sheet. The lower or tubular shell was 16 feet long and 60 inches in diameter, containing 52 tubes, each $4\frac{1}{2}$ inches in diameter and 16 feet long. Under these was a manhole, 11 in. × 14 in. The drum or upper part was 17 feet long and 48 inches in diameter, with a manhole 11 in. × 14 in. through the second sheet from the front end.

The thickness of the plates varied from 0.36 in. to 0.39 in., — evidently intended to be $\frac{3}{8}$ in. The rivets used were $\frac{3}{4}$ in. in diameter, the longitudinal joints being double riveted and the girth joints single riveted. The pitch of rivets in the drum was $2\frac{1}{8}$ in. In the lower or tubular portion the pitch was a little less than this, eleven rivets just making 23 inches in length. The plates were all stamped with the maker's name, and marked "C. H. No. 1. Flange. 50,000 lbs."

Where the sheets were pulled apart they showed little or no reduction of area, and the fracture was not what would be expected from good iron. Portions of it were afterwards tested and bent, both hot and cold. Some seven or eight tensile tests were made, with results varying from 35,000 lbs. to 54,000 lbs. to the square inch, and with an elongation not greater, in any case, than 4 per cent. Some of the pieces showed none whatever. It was found that the sheets would not bend to a radius of 4 feet without breaking, and some were so brittle that they would not bend at all. Heating the metal red hot seemed to make it worse, rather thin better, in this respect. It may be added that the test pieces were taken from parts of the sheets that were considered to be uninfluenced by the shock of the explosion.

The location of the principal fragments of the exploded boiler will be seen in Fig. 2. The upper shell, together with the necks attached to it, and the rear sheet of the lower shell, was blown some 200 feet lengthwise of the mill, crossing the street and striking against the second story of another mill, after which it fell back and lodged on the curb of the sidewalk. The rear head, with 14 tubes clinging to it, landed about 75 feet from the boiler-house in a direction nearly at right angles to the course followed by the first fragment. Twelve tubes were found lying beside it. This head landed just as it was in the boiler. The sheet had torn off through the line of rivets around the flange, leaving the caulking edge of the sheet a perfect ring on the head outside of the rivets. The front head went clear of the tubes and lodged against a bank wall about half as far away as the back head. The front sheet was hanging to it, torn off all but about a foot, and a portion of the second ring of plates clung to it likewise, well twisted up. Another ring and a half of plates went toward the right in the cut, landing about 70 feet away. These rings were badly torn up. None of the pieces showed signs of overheating.

It is not easy to say just how the explosion occurred. It took place at the noon hour, when the fire was banked and the damper and ash-pit doors were closed and the fire doors partly open. Ordinarily, 80 lbs. of steam were carried, but it is maintained that the pressure was only 70 lbs. at the time of the explosion. The sheets were so badly torn up that it was very difficult to decide where the initial rupture occurred. We did not insure this boiler, but, in the opinion of one of our inspectors who visited the place shortly after the explosion, a fracture had started along one of the horizontal riveted joints some time previously. This is borne out by the engineer's testimony. He heard a hissing noise, as of escaping steam, on the Thursday or Friday before the accident happened. Thinking that a leak had started somewhere he looked about for it, but without success. Afterward he thought the noise stopped, but on Sunday he went into the rear end of the setting to see if the tubes were leaking, and found that they were not. The explosion occurred on the following Tuesday. If a fracture had started along one of the joints it would extend rapidly in the kind of iron that the boiler seems to have been made of. The pitch of rivets in the lower shell being $2\frac{1}{8}$ in., and the diameter of the rivet holes being $\frac{13}{16}$ in., the strength of the joint was about 62 per cent. of the strength

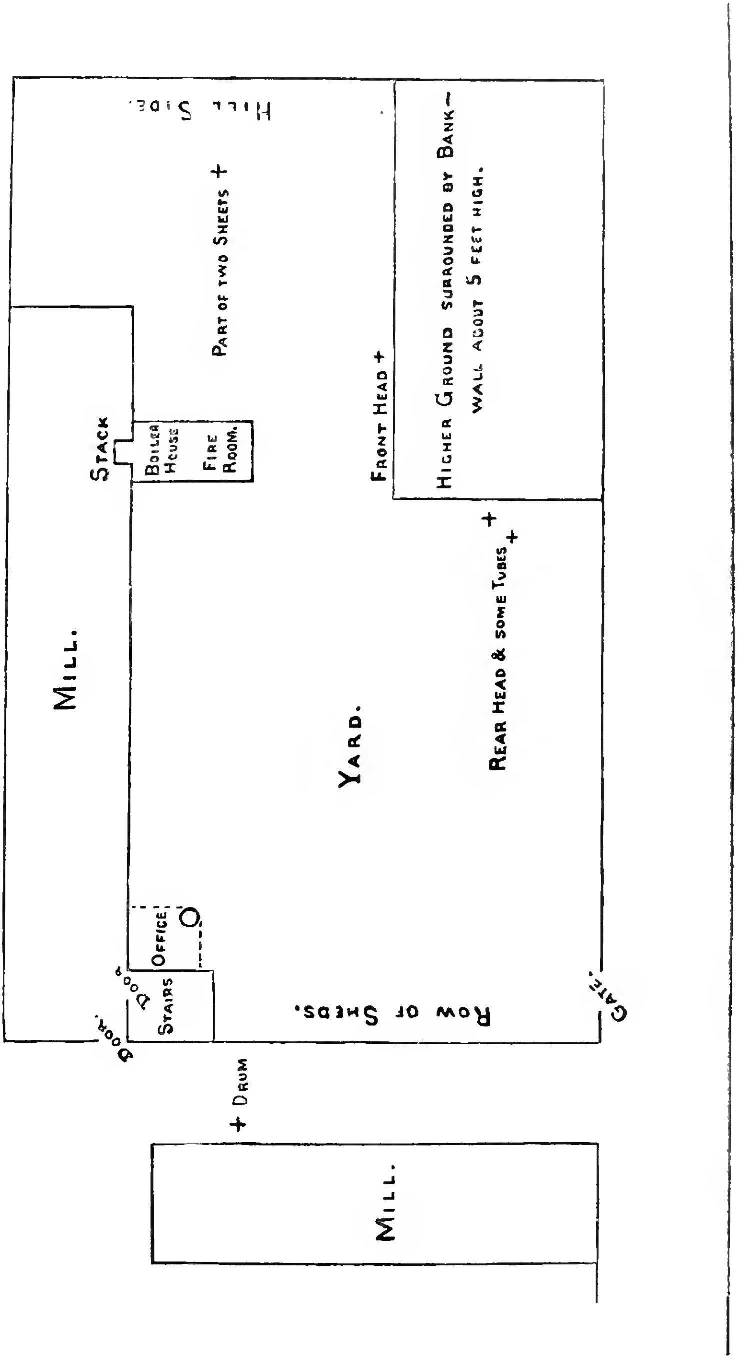

FIG. 2. — PLAN OF MILL AND YARD.

of the solid plate. If we take the lowest strength found in the tensile tests afterwards made — 35,000 lbs. — we have, as the bursting pressure:

$$(35{,}000 \times .62 \times \tfrac{3}{8}) \div 30'' = 271 \text{ lbs.}$$

This, of course, assumes that the workmanship was perfect, and that there was no deterioration by grooving or corrosion. With a factor of safety of 5, the safe working pressure would be 54 lbs. If the boiler was habitually run at 80 lbs., the pressure no doubt exceeding this by a few pounds at times, it is not difficult to believe that the metal may have been strained beyond its elastic limit and a fracture developed at the joint in the course of time, as our inspector has suggested. This is particularly likely to have been the case, if we take into account the poor quality of the iron, as shown by the tests.

The boiler-house was annihilated by the explosion, and the post supporting the outer corner of the office of the mill was knocked away, so that the office and its contents fell to the ground, but, fortunately, no one was in it at the time. Most of the glass on the boiler-house side of the mill was broken, but no further damage was done to the mill, and little or none to the machinery.

The hands that ate their dinners at the mill were in the habit of going into the yard after dinner to play ball. Had the explosion occurred ten or fifteen minutes later, there would have been a dozen or more of them in the yard playing, and the loss of life would probably have been considerable. Two boys, who came to bring some of the hands their dinners, were killed. There was no other loss of life, and nobody was injured.

Boiler Explosions.

February, 1891.

Pulp Mill (22). The boiler in Carricade's pulp mill at Milton, N. H., exploded on Feb 1st, wrecking a portion of the mill. The amount of damage was not great.

Locomotive (23). The boiler of a passenger train locomotive on the Cleveland, Canton & Southern Railroad exploded on Feb. 3d near Cleveland, O. The engineer and fireman were killed, but the passengers were not injured.

School (24). There was no session of the high school in Portsmouth (N. H. ?) on Thursday, Feb. 5th, owing to an accident to the boiler of the heating apparatus. The water in the boiler was allowed to get too low, while there was a hot fire, and when cold water was turned in, a rupture occurred, fortunately without disastrous result. The damage is several hundred dollars. No one was hurt.

Oil Well (25). The boiler of an oil well being drilled on the Hamilton farm near New Wilmington, Pa., exploded at 11.30 on Feb. 5th, killing Fred Johnston instantly. The engine was torn down and pieces of the boiler thrown 500 feet. Three men near the hole had remarkable escapes, not receiving any injuries, although only about 15 feet from Johnston.

Saw-Mill (26). The boiler at the saw-mill of William E. Osmore, near Leavenworth, Ind., exploded Friday, Feb. 6th. Edward Bowman, George Saltsgiver, Victor Palmer, and Joseph Elliott were seriously injured. Elliott cannot recover. The boiler was blown 175 feet away and the machinery badly damaged.

Saw-Mill (27). A boiler in Robert Giles' steam saw-mill on the Ohoope river, three miles south of Reidsville, Ga., exploded on Feb. 7th, killing six people — two white and four colored. The mill was a large one, and was sawing orders for lumber firms in Savannah. The fire under the boiler was kept banked, and everything was thought to be all right when the night watchman was relieved by the fireman in the morning, but as soon as the fireman opened the injector, the boiler exploded with terrific force, destroying the building and killing or wounding every person near it, and setting fire to the debris.

Iron Furnace (28). A serious explosion occurred on Feb. 9th, at the Pulaski Iron Company's furnace. Pulaski, Va. One man, John Henry Hemmerly (white), was seriously hurt and possibly mortally. Two others received slight wounds. The engine, boiler, and roof were demolished. The amount of damage is not known. The whole furnace had, last fall, been put in perfect order.

Planing Mill (29). The boiler in Pettefer Bros.' planing mill, on Cumberland between Markham and Second streets, Little Rock, Ark., exploded with terrific force on Feb. 10th, about 9.30 o'clock. The boiler-house was completely wrecked, the neighborhood receiving a shower of bricks that broke hundreds of panes of window glass. Several bricks were hurled through a front window of the *Evening Democrat's* office, two blocks distant from the scene of the disaster. Parts of the boiler were hurled five blocks away from the mill, a portion of the iron landing upon the roof of Hotel Baker, 200 yards from the wreck, and many of the bricks passing through the rear windows of the hotel. No one was injured by the accident. The damage to the mill and surrounding property is estimated at $10,000. "The sudden thawing of the pump, which the engineer believed was in working order," says the newspaper account, "is said to have caused the accident." If this is the fact, it would be well to keep the pump in a freezing mixture hereafter.

Tug-Boat (30). On Feb. 11th two tug-boats, the *Alice P. Egbert* and the *S. W. Morris*, were landing the bark *Bruce* in the Kill Von Kull, when she listed to starboard and sank, carrying the *Morris* with her. As the *Morris* went down her boiler exploded, and witnesses say that she broke in two. No one was hurt, but the loss was considerable.

Woolen Mill (31). A boiler exploded at James O. Inman & Son's woolen mill, Pascoag, R. I., on Feb. 11th. The explosion occurred at night when there was but little fire under the boiler. The loss was in the vicinity of $8,000.

Pulp Mill (32). The combination pulp and straw-board mill at Elkhart, Ind., exploded on Feb. 12th with terrific force, demolishing the large brick mills and utterly ruining the plant. Schuyler Neswander, aged twenty-five, was blown three hundred feet and torn to pieces. George Hickman was crushed and will die. Foreman Fleming and his assistant, Wilson, were also badly hurt. The Muzzy Starch Mill, across the race, was dismantled by the explosion.

Worsted Mill (33). About 9.45 o'clock, on Feb. 12th, a boiler in the Quebec Worsted Company's factory, at Hare Point, near Quebec, exploded, completely demolishing the engine-house and factory, and burying thirty or more employes in the wreck. The works of the Quebec Worsted Company covered a large area, and the company employ more hands than any other manufacturing establishment in the city. They had been closed down for two weeks while the boilers and machinery were being overhauled and refitted. Operations were to have been resumed on the morning of the explosion, and about 300 of the operatives were on hand. Owing to some cause the machinery was not started and they were dismissed. Many of them, however, remained about the building, a number keeping in the vicinity of the engine-room for the sake of warmth. About 9.45 there was a sudden explosion which completely wrecked the engine-house and a large part of the main building. A great crowd gathered immediately and the work of rescue began. The fire brigade was called out, but was not needed. A battery of artillery was also called out to assist the police in keeping order and controlling the enormous crowd of excited men and women who blocked every avenue of approach.

FEED-MILL (34). On Feb. 12th the boiler of a feed-mill at Ritzville, near Portland, Ore., exploded, wrecking the mill building badly and destroying the chop mill. There were two men in the mill at the time, one at work on the boiler, and, strange to say, neither of them were injured.

FLOURING MILL (35). By a boiler explosion in the flouring mill of Churchill & Owsley, at Windsor, twenty miles south of Sedalia, Mo., on Feb. 13th, Hugh L. Smith and Tom Tillberry, boiler-makers, who were at work on the boiler, and Walter Beaman, engineer, and Charles Sturtevant, a miller, were instantly killed. The large mill was blown to atoms. A boiler exploded in the same mill nineteen years ago.

WOOD YARD (36). On Feb. 14th a boiler in John Plotz's wood yard, New Albany, Ind., exploded, cutting off the right leg of John Sherrer, the engineer, and otherwise injuring him, so that he will probably die. He was blown entirely across the lot, a distance of over forty feet. The boiler was hurled a hundred feet upward and the building torn to pieces. No one else was seriously hurt, though several of the employes were slightly injured and scalded.

LOCOMOTIVE (37). An engine exploded on the Western & Atlantic railroad on Feb. 16th. The scene of the accident was at Marietta, near Chattanooga, Tenn. The engineer and fireman left the cab when the engine reached the depot, and while the engineer was getting telegraphic orders, the explosion occurred. It is reported that every window in the depot was shattered and also the windows of several houses near by. A flying missile from the exploded boiler struck the fireman and severely injured him. The train was a freight.

GRAIN ELEVATOR (38). The boiler of an engine used in Ashbrook & Watkins' elevator, at Humbolt, near Mattoon, Ill., exploded with terrific force on Feb. 18th, instantly killing Wm. Watkins, who was attending to the duties of engineer in the absence of the regular man, who was sick. It is said that the boiler had a faulty safety-valve. Several men in the building and vicinity had narrow escapes from death. The windows on one side of the Illinois Central Depot were demolished and fragments of the boiler were driven through the wall of the building in close proximity to the operator and passengers, while portions a yard square were found two blocks away.

STEAMBOAT (39). A bad accident occurred on Feb. 18th on the Little Kanawha river, near Parkersburg, W. Va., by the explosion of the boilers of the steamer *Oneida*, the largest on the river. At the time there were seven passengers on board and a crew of eleven, including Capt. Rathbone and Engineer King, who were terribly scalded. One of the passengers on the steamer says: "As the *Oneida* was rounding the curve two miles from Newark, there was a sudden and awful explosion, followed by an immense volume of steam, which entirely concealed the rear end of the boat. The next second the boat had taken fire by the hay on board igniting. By the rarest good fortune every passenger was in the front of the boat. The only lady on board was in the office. When the steam partly cleared away it was seen that the middle and rear parts of the cabin were blown entirely off and that the boat was at the mercy of the waves. Fortunately, it floated to the shore. At the time of the explosion Engineer King was on duty and he was terribly burned. Capt. Rathbone was thrown into the air and fell among the boilers. He was badly scalded. The floor was torn away from under the kitchen and the cook was found hanging to the stairway. A few minutes after the steamer *Hilton* came up, took the passengers and wounded off and brought them here. The *Oneida* is a bad wreck."

Paper Mill (40). The head blew out of the large rotary boiler at the Union paper mill, New Hope, Pa., on Feb. 18th, shattering the building in a fearful manner. One side of it was completely blown out, and the upper floor and the roof will have to come down. Thomas Moore was struck on the head with a piece of timber, and was also slightly, but not seriously, scalded.

Saw-Mill (41). The boiler at Pike's saw-mills, a few miles east of Roanoke, Ala., blew up on Feb. 19th, with fatal effects. The safety-valve was out of fix and the steam gauge was defective. Two men, Olin Weaver, a negro, and a Portuguese named Henry Lloyd, were attending to the boilers and firing. When the explosion came, Olin Weaver was putting in more wood. He was blown forty yards from where he was standing, striking a pine tree fully fifty feet from the ground. His right arm and the furnace door were found more than 100 yards away. Pierce Pike, one of the owners of the mill, had his left leg shattered and was terribly scalded. Harry Bennet had two ribs broken and was very severely scalded about the legs and lower part of the body. He is severely, though not dangerously, injured. Harry Lloyd, who was working about the engine, is badly scalded, as were also Caleb Kirby and an unknown negro. The engine was turned over by the explosion, and was stopped by obstructions more than 100 feet from where it originally stood.

Saw-Mill (42). At Madoc, near Belleville, Ont., a boiler exploded in Casselman's saw-mill on Feb. 21st. One of the proprietor's sons was fatally scalded and another was severely injured. The building was completely wrecked.

Locomotive (43). On Feb. 22d the freight train of which Mr. Clifford Shanks was the engineer left the depot in Petersburg, Va., for Norfolk. Just as the train reached the vicinity of the iron bridge near the eastern limits of the corporation, the engine boiler exploded, blowing off the crown-sheet, the flue-sheet, and the fire-box. The front of the boiler was also blown out. Had the explosion been upward instead of downward, the consequences would probably have been much more serious. Engineer Shanks escaped unhurt, but Fireman Beasley was terribly scalded. He was in the act of feeding the furnace when the explosion occurred, and he was blown back into the tender. His face, hands, and legs were badly scalded by the steam. A colored brakeman was also slightly scalded.

Saw-Mill (44). A boiler in M. M. Trimmer's saw-mill, Centerburg, O., exploded Tuesday morning, Feb. 24th. Ed. Dailey and Amos Montgomery narrowly escaped being killed. They had just left the boiler and were rolling a log. Pieces of the boiler were thrown several hundred feet.

Saw-Mill (45). Orren Newberry was killed by a boiler explosion on Feb. 26th at Fred Ladow's saw-mill, at Cornplanter Run, Elk township, near Warren, Pa. Newberry was standing at the side of the boiler when the explosion took place. A 9-year-old boy, Claude Atridge, who was in the boiler-house with Newberry at the time of the explosion, was also killed. The explosion completely demolished the boiler-house and a part of the mill. Young Atridge was struck in the back of the head by a piece of the boiler. He lived about an hour, but was unconscious.

Box Factory (46). About 3 o'clock on Feb. 27th one of the boilers at the works of Varney & Hayes, on Granite street, Haverhill, Mass., burst, causing a suspension of power in their box factory and in the places depending upon their engine. The direct damage was slight. The engineer was badly scalded about the face by the escaping steam.

Saw-Mill (47). The boiler of a portable saw-mill exploded Feb. 27th at a point fifteen miles south of Cairo, Ill. John Corbbes and Sam Dowdy were killed, and two others, names unknown, were fatally injured. The engineer was thrown 150 yards.

The Wave Theory of Sound.

In our issue for March there is an article on Dr. A. Wilford Hall's "substantial" theory of sound. We have a few more words to say about it.

In the first place, Dr. Hall does not appear to be aware of a very important distinction that ought to be very clearly made in discussing this subject. He seems to be troubled by the law of decrease of sound-intensity as we draw away from a sounding body. Now, while it is true that the physical intensity of sound diminishes in proportion as the square of the distance increases, it is not maintained by any physicist of eminence that the impression a sound produces on our ears diminishes in that proportion, or in anything like that proportion; for in discussing the *apparent* loudness of a sound we must take account of Fechner's or Weber's law. This law says that, for moderate ranges of intensity, the effect produced on our senses by a given stimulus is not proportional to the stimulus, but that *the effect increases in arithmetical proportion as the stimulus increases in geometrical proportion.*

Mr. Andrew Seth says, in discussing this law in its relation to the sense of touch, "We are unable to recognize slight differences in weight when the weights compared are heavy, though we should be perfectly able to make the distinction if the weights compared were both light. Ordinary observation would lead us, therefore, to the conclusion that the greater the intensity of the original stimulus at work, the greater must be the increase of stimulus in order that there may be a perceptible difference in the resulting sensation. E. H. Weber was the first (after a prolonged series of experiments on the sensations of sight, hearing, and touch) to clothe this generality with scientific precision by formulating the law that has since gone by his name. The purport of the law is that, in order that the difference in sensation may remain unchanged, the increase of stimulus must maintain the same proportion to the intensity of the preceding stimulus. For example, if we can just distinguish 16 oz. from 17 oz., we shall be able to distinguish 32 oz. from 34 oz., the addition in each case being $\frac{1}{16}$ of the preceding stimulus; but we should be unable to distinguish 32 oz. from 33 oz. This fraction ($\frac{1}{16}$th) remains constant however light or heavy the weights compared may be." We can, therefore, distinguish 1 oz. from $1\frac{1}{16}$ oz., or 100 lbs. from 106 lbs. "The law," continues Mr. Seth, "may be formulated thus: In order that the intensity of a sensation may increase in arithmetical progression, the stimulus must increase in geometrical progression." It is also expressed by Fechner as follows: "The sensation increases as the logarithm of the stimulus."

The thoughtful reader will see that if this law is applied to the sense of hearing (for which sense it is most accurate), it will follow that when the ear is at a distance from the source of sound, it does not by any means follow that the sensation we perceive is as faint as Dr. Hall would have us believe it ought to be. For example, suppose two people are listening to a steam whistle, one of them, whom we will call *A*, being 100 feet away from it, and the other, *B*, 10,000 feet, or two miles, away. If we suppose the apparent loudness of the sound to be proportional simply to the inverse square of the distance, the whistle should sound 10,000 times as loud to *A* as it does to *B*; but if we take account of Weber's law of sensation, it appears that the whistle will seem only twice as loud to *A* as it does to *B*. This is certainly much nearer the actual state of things than the result of the first supposition we made. It must be said, however, that Weber's law is only approximately true, like all other laws of similar character; and that when the differences in physical loudness are great, as in the example just given, it cannot be expected to give anything more than an approximation to the truth.

We have given considerable space to the discussion of the law of sensation, because it is of extreme importance in discussions relating to sound, and Dr. Hall does not appear to know anything about it. In all probability it goes a long way toward explaining why the notes of the grasshopper and katydid can be heard so far, though there are other causes that must be taken into account in connection with these insects. For instance, owing to the construction of the ear, the apparent loudness of a sound depends not only upon its physical loudness (which varies as the inverse square of the distance,) but also, and largely, upon its pitch and *timbre* or character. These points are discussed to some extent by Helmholtz in his *Sensations of Tone;* and since we do not find them referred to in Dr. Hall's paper, we infer either that he has not read Helmholtz thoroughly, or that he found them uncomfortable points to discuss.

Now, a word as to the velocity of sound in wood and iron. Dr. Hall seems to think that he has found something here that puts the wave theory *hors de combat*. But we are sure the doctor does not imagine that the figures he gives for these substances were obtained by direct measurement, for that would imply that a mass of iron two or three miles long had been experimented with; and even though this might be possible, nobody will hold that the velocity of transverse propagation through wood could be determined directly, for trees do not grow to be more than a few feet in diameter. There are several methods of determining the velocity with which sound moves through solids, but all of them are based on the wave-theory, and therefore the figures that he gives, being obtained by means of the wave-theory, cannot be used to overthrow this theory, since they necessarily agree with it. One way of finding the velocity of sound in solids is to determine the pitch of the note produced when a rod of the substance under examination vibrates endwise. Let the pitch number of this note be n, and let the length of the rod be l feet; then the velocity of sound in the substance is $2\ n\ l$ feet per second.

If our space would allow it, we should be pleased to examine each one of Dr. Hall's difficulties in detail. Perhaps enough has been said, however, to show that he has been hasty in concluding that "the wave-theory must go." It has, for several centuries, been attacked from all points of view, but the assaults upon it have had a tonic effect, like a spring medicine; and it has grown into a healthy and lusty creature — hard to get well acquainted with, perhaps, — but improving marvelously upon such acquaintance.

THE Mosque of St. Sophia in Constantinople, says the *St. Louis Republic*, is always fragrant with the odor of musk and has been so for hundreds of years, ever since it was rebuilt in the ninth century; the curious part of it being that nothing is done to keep it perfumed. The solution to the seeming mystery lies in the fact that when it was built, over 1,000 years ago, the stones and bricks were laid in mortar mixed with a solution of musk.

The Locomotive.

HARTFORD, APRIL 15, 1891.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

THE LOCOMOTIVE *can be obtained free by calling at any of the company's agencies.*

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Bound volumes one dollar each. (*Any volume can be supplied.*)

Papers that borrow cuts from us will do us a favor if they will plainly mark them in returning, so that we may give proper credit on our books.

WE have received a copy of W. H. Ford's *Boiler Making for Boiler Makers* from the publishers, Messrs. John Wiley & Sons, New York. It is an excellent little book, written by a man who has had practical experience in the matters whereof he writes. He discusses riveting, bracing and staying, flanging, welding, annealing, smithing, punching and drilling, cold bending, calking, tube-setting, and other matters, all in an intelligent and intelligible manner. The book is small and handy, and it is fully and graphically illustrated.

Time was, when we used to take delight in reading the poets; but the indications are, as Macaulay has pointed out, that the age of poetry is passing away. We are coming to regard unusual mental conditions as indications of pathological irregularities, rather than as manifestations of the soul, and to-day the melancholy Dane would probably be restrained of his liberty and treated for chronic cerebral anæmia or enlargement of the liver. What, for instance, was more touching than to think of beautiful maidens dying of broken hearts when their lovers forsook them for others, with charms perchance as fair to view? Yet see how the *London Lancet*, in these later days, lays bare the physiological and pathological conditions that we might expect to find in the viscera of these maidens:

"That severe mental distress or fright sometimes produces physical disease, and occasionally even death, is an admitted fact, although the way in which it acts has hitherto been but little studied. In order in some measure to supply the deficiency in our knowledge regarding this matter, Dr. G. Bassi has recently made a number of observations on animals which apparently died in consequence of capture. Birds, moles, and a dog which had succumbed to conditions believed by Dr. Bassi to resemble those known among human beings as acute nostalgia and 'a broken heart' were examined post mortem. Generally there was hyperæmia, sometimes associated with capillary hemorrhages of the abdominal organs, more especially of the liver, also fatty and granular degeneration of their elements, and sometimes bile was found in the stomach with or without a catarrhal condition. The clinical symptoms were at first those of excitement, especially in the birds, these being followed by depression and persistent anorexia.

"The theory suggested by Dr. Bassi is that the nervous disturbance interferes with the due nutrition of the tissues in such a way as to give rise to the formation of toxic substances — probably ptomaines — which then set up acute degeneration of the parenchymatous elements similar to that which occurs in consequence of the action of certain poisonous substances, such as phosphorus, or to that met with in some infectious diseases. In support of this view he points out that Schule has found parenchymatous degeneration in persons dead from acute delirium, and that Zenker found hemorrhages in the pancreas in persons who had died suddenly; he refers also to some well-known facts concerning negroes in a state of slavery and to the occasional occurrence of jaundice after fright. He hopes that these hints may induce medical officers of prisons and others to study both clinically and anatomically this by no means uninteresting or unimportant subject."

The Game of Chess.

Mr. W. Steinitz, the champion chess master of the world, speaks of his favorite game as follows: Some of the foremost thinkers have spoken in the highest terms of the game of chess as an intellectual amusement and as a mark of great capacity, and some of the greatest celebrities of different nations have devoted time and attention to the study and practice of its intricacies. Goethe, in his translation of "Le Nepheu de Rameau," by Diderot, endorses the opinion of the celebrated French philosopher who describes it as "the touchstone of the human brain." Prince Bismarck, in disparagement of mere rhetorical ability, once remarked that "great orators, as a rule, cannot play a good game of either chess or whist," which shows that this pre-eminent statesman thought more highly of the capacity for playing games of skill as a test of acumen than he did of the oratorical faculty. Ex-President Grèvy of France is a great lover and supporter of the game, and during his presidential term he offered prizes from the public funds for national and international chess tournaments in France. Buckle, the author of "The History of Civilization," was one of the greatest chess masters of our age. Liebnitz, Voltaire, Lessing, Mendelssohn, Alfred de Musset, Frederic the Great, Napoleon I, and William I, were fond of the game, and most of them are reported to have acquired great skill as players. The literature of the game belongs to the oldest on record in many languages, and its rapid increase in our time has been greatly instrumental in reviving the general popularity of our pastime, as it has facilitated the study of the openings and of practical examples of play between masters. The spread of the game all over the civilized world is, however, chiefly due to the inauguration of international chess congresses and matches between experts, which from time to time are organized in the principal capitals of Europe and the American continent. These public exhibitions of chess skill have been watched with the keenest attention by lovers of the game literally all over the face of the globe, for not alone the results of play but whole records of games have been communicated through the medium of the newspaper press and the cable to the widest distances on our planet. Fresh talents have been constantly drawn out by those public tests of strength which have formed the training schools for some of the greatest masters of our time, who have developed novel theoretical and practical ideas that greatly help students of the game to overcome the chief difficulties in mastering the intricacies of our pastime. These difficulties were in former days considered quite insurmountable, and proficiency in the "art of humau reason," as chess has been aptly termed by Gustavus Selenus, was held to be the special privilege of the few. But experience has undeniably shown that prominence and even excellence in chess may be acquired in a manner similar to that in which proficiency may be obtained in other accomplishments that require mental exertion, and that with proper training and study the large majority of learners may generally improve their chess strength up to a very high degree, at least, and sometimes to mastery.

The Loves of Inventors.

Inventors do not, as a rule, make good lovers. The man whose brain is full of some great mechanical project, whose heart and soul are centered on the achievement of some wonder of wheels or pulleys, or fire or steam, has not much room for the softer feelings which supply so much of the poetry of common humanity. His love is given to his invention. Of it he dreams by day as well as by night; for it he makes his sacrifices, undergoes privations, and waits and labors with such patient endurance. He will often woo and marry, after the manner of men, but he will never become the "moonstruck," love-lorn individual which more purposeless men are capable of becoming. He will be a business-like, rather than an ardent, lover; and will make a dutiful, rather than an affectionate, husband: the romance of his life is his life's work, his invention, and as that goes well or ill so will his heart be light or heavy.

Some inventors have been far from happy in their lives. Arkwright had but a sorry time of it with that spirited "Lancashire lass," his second wife, who smashed the model of his spinning frame one day in a fit of temper, because she deemed it (and perhaps not altogether unjustly) responsible for their poverty. What she thought of it all when, after separating from him, he accumulated a large fortune and allowed her £30 a year out of it, the annals of cotton-spinning do not inform us. We are told, however, that she never spoke ill of him, and would not permit any one else to do so in her hearing.

Bernard Palissy complained bitterly of the impatience of his wife under the long trials of his experiments in enamels. "Even those from whom solace was due," he said, "ran crying through the town that I was burning my floors, so that I was regarded as a madman." Sir Humphry Davy, the inventor of the Davy lamp, found love something of a delusion, if not a snare. Writing to his mother, he said, "I am the happiest of men in the hope of a union with a woman equally distinguished for virtues, talents, and accomplishments." And in a letter to his brother he expresses his rapture thus: "Mrs. Apprece has consented to marry me, and when the event takes place, I shall not envy kings, princes, or potentates." The widow must have been a person possessed of great powers of fascination, for Sir Henry Holland makes mention of her as a lady who made such a sensation in Edinburgh society that even a regius professor did not think it beneath his scholarship to go down on his knees in the street to fasten her shoe. The sequel need not be dwelt upon further than to add that the marriage turned out to be altogether a mistake. Lilly, the astrologer and alchemist, could not see for himself sufficiently far into that future which he professed to be able to scan so clearly for others, to guard him against making a fool of himself by marrying. He caught a vixen, "of the temper of Mars," to use his own words, and the fact that she brought him £500 as dowry did not count for much in the way of compensation, seeing that "she and her relations cost him £1,000."

But this was a trifling error of perception compared with that committed by Sir Samuel Morland, who, besides being secretary to Lord Thurlow and master of mechanics to Charles II., invented a speaking trumpet and other ingenious articles. Writing when smarting under the pain of heartless deception, he says: "About three weeks or a month since, being in very great perplexities, and almost distracted for want of money, my private creditors tormenting me from morning till night, and some of them threatening me with a prison, there came a certain person to me, whom I had relieved in a starving condition, and for whom I had done a thousand kindnesses, who pretended in gratitude to help me to a wife, who was a very virtuous, pious, and sweet-dispositioned lady, and an heiress who had £500 per annum in land of inheritance and £4,000 in ready money, with the interest since nine years, besides a mortgage upon £300 per annum more, with plate, jewels, etc. The devil himself could not contrive more probable circumstances than were laid before me; and when I had often a mind to inquire into the truth, I had no power, believing, for certain reasons, that there were some charms or witchcraft used upon me, and withal, believing for certain it utterly impossible that a person so obliged should be guilty of so black a deed as to betray one in so barbarous a manner. Besides that I really believed it a blessing from heaven for my charity to that person, and I was, about a fortnight since, led as a fool to the stocks, and married a coachman's daughter not worth a shilling; and thus I am both absolutely ruined in my fortune and reputation, and must become a derision to all the world." Sir Samuel, however, was too clever a man to allow himself to be kept down by such unholy fetters as these; besides, he lived in an age when the obligations of matrimony were at best but lightly regarded; so he survived the humiliation that his marriage brought upon him, and managed to forget the coachman's daughter in the courtly atmosphere in which he long moved.

It is pleasant to turn from a picture like the foregoing to one of the few stories in which it is clearly shown that the passion of love has had a real influence in advancing the interests of the inventor.

On the tomb of Quentin Matsys, erected a hundred years after his death in the cathedral of Antwerp, are inscribed in letters of gold the words: "*Connubialis amor de mulcibre fecit Apellam.*" ["Connubial love made him an Apelles."] It was, indeed, his pure love for a beautiful woman that was the inspiration of all his greatness. The "blacksmith of Antwerp," as he came to be styled, was born in poor circumstances in the year 1466, and for a long time supported himself and his mother by working as a locksmith. It was while laboring in this humble capacity that he fell in love with the daughter of a painter of Antwerp. The difference in their stations seemed at first an insurmountable obstacle to the success of his suit, but the ardor of his passion made him eloquent, and the comeliness of his person made him attractive, and he in the end won the heart of the young lady, and they might have been united had his rank in life been equal to hers. As it was, the painter declared that no one but an artist should have the hand of his daughter, and had already in his mind set apart a certain youth of birth and parts, one of his own pupils, for the honor. Even the damsel, prepossessed as she was in favor of Quentin, could not think of marrying a common blacksmith; so with some insight doubtless into the young man's natural powers, she told him that his suit was hopeless unless he could transform himself from a blacksmith into an artist, and excel the rival whom her father favored.

It was this that made an artist of Quentin Matsys. From locks and bars he turned himself, first of all, to decorative iron-work, and constructed for the well of the great church of Antwerp, and for the College of Louvain, specimens of such work which gained him great praise for the remarkable delicacy of execution and chasteness of ornamentation which they displayed. His next task was to make a series of exquisitely modeled images of the saints for distribution amongst the people on the occasion of a festival of the Roman Catholic Church, and so much were these admired that they increased his fame considerably. Still, this was not sufficient for the proud painter whose daughter Quentin loved with such an ardent devotion; Quentin was only a worker in iron after all. The "blacksmith of Antwerp" did not despair, however, for, though he was in delicate health, and as yet did not see clearly what was to be done to gain the chief desire of his life, the artistic instinct was strong enough within him to give him hope. For a time, therefore, he shut himself up, and studied the art of painting with so much diligence that it was not long before he produced a work which he considered worthy of being shown to the father of the young lady with whom he was in love. He took it to him, and the father was so delighted with the painting, that he there and then withdrew all objection to the proposed marriage, and in due course Quentin Matsys and the painter's daughter became man and wife. Many of his artistic productions in iron and on canvas remain to this day in the art collections of Europe to give their testimony to the leading influence in the life of this remarkable man, the influence of a pure and simple love.

Crompton fell in love with a comely young woman of his own station because of her expertness as a spinner on Hargreaves' jenny, and when they set up house together in the little cottage attached to the "Hall i' th' Wood," she afforded him her affectionate aid in working out the models of his famous "mule." Brindley did not fall in love until he was nearly fifty. His biographer speaks of him as having "little time for friendship, and still less for courtship." But at the house of John Henshall, the land surveyor at Bent, near New Chapel, he found a young lady (Henshall's daughter Anne) whose presence was so pleasing to him that he generally took her a pocketful of gingerbread when he visited her father's house. He ultimately proposed to her and was accepted, and they were married, she being nineteen, he forty-nine. Dr. Smiles suggests that "the union may have been quite as much a matter of convenience as of love on his part." After the marriage she managed all his correspondence, and proved herself a "most clever, useful, and affectionate partner."

George Stephenson was too busy a man to have much time for love-making; he was practical in this as in other affairs, and did not go far afield for his choosing. It was while at Black Callerton, fulfilling the duties of brakesman at the Dolly pit, that the idea of marriage seems to have occurred to him as an advisable step; and as an evidence of his earnestness in the matter, when once he had made up his mind, it need only be mentioned that he made three proposals of marriage in one year. He was at that time lodging in the farmhouse of Thomas Thompson. Miss Hindmarsh, a farmer's daughter, was the first damsel he made an offer to, and she accepted him; but the farmer would not hear of it, and sent the young engineer about his business. A brakesman with about a pound a week was not considered good enough for the farmer's daughter by any one except herself, and "northern farmers" had in those days a way of enforcing obedience upon their offspring which was effective, if a little rough.

George was doubtless disappointed at being snubbed by the farmer, but he did not fret; he simply "made up" to another young lady, or rather, to two, and tackled the matter in a fair business spirit. There was a servant-girl named Fanny Henderson, living in a farmhouse in which Stephenson lodged, with whom he was on terms of friendliness. Fanny had several sisters, who visited her from time to time, and it was with one of these (sister Ann, in fact) that George next fell in love. It was for Ann (wrote Mr. Pattison, her nephew) that George mended the shoes which Dr. Smiles refers to as having been carried about in the brakesman's pocket on the Sunday afternoon after they were finished, when George every now and then pulled them out and held them up, exclaiming, "what a capital job he had made of them." Ann Henderson was, we are told, the youngest and prettiest of the sisters; but she was not at all smitten with the amateur shoemaker and jack-of-all-trades, so George, determined to go no further in his love quest than this family circle would take him, at last proposed to the faithful and industrious Fanny, not at all held back by the fact that she was twelve years his senior. There was no "lang coortin'" to follow. After his removal to Willington Quay, to take charge of the engine on Willington Ballast Hill, at an increased wage, he, on the 28th of November, 1802, married Fannie Henderson at Newburn Church. The age of the bride was thirty-three; that of the bridegroom twenty-one. It is worthy of note that the future author of railway traveling had to be content to make the bridal journey in the most primitive of fashions. "Two farm horses," says his biographer, "borrowed from a neighboring farmer, were each provided with a saddle and pillion, and George having mounted one, his wife seated herself behind him, holding on by his waist. The bridesman and bridesmaid in like manner mounted the other horse; and in this wise the wedding party rode across the country, passing through the old streets of Newcastle, and then by Wallsend to Willington Quay, a ride of about fifteen miles." Fanny made George an affectionate wife, and the two lived happily together for the few years of their married life. George's only son, Robert, who was destined to almost equal his father in fame, was born in October, 1803, and in 1806, shortly after giving birth to a daughter, the devoted wife died, and "George felt as one that had thenceforth to tread the journey of life alone." And for fourteen years George Stephenson remained a widower, happy in the affection of his son, and occupied year by year with increasing business responsibilities; but in 1820, when fortune was beginning to smile upon him, he again proposed for the hand of his first love, Elizabeth Hindmarsh, the farmer's daughter, and this time no objection was raised to the alliance, and the couple were married at Newburn Church on the 29th of March, 1820. There has been much written concerning George Stephenson's life from 1820 down to the period of his death in 1848; but hardly a single glimpse are we permitted to have of the domestic side of his career during those twenty-eight years.

James Nasmyth, the inventor of the steam-hammer, relates, in his autobiography, the story of his falling in love, and for once we get a touch of the romantic in an inventor's loving. After confessing that he had had "few opportunities of enjoying the society of young ladies," he goes on to say: "I had occasion to make a business journey to Sheffield on the 2d of March, 1838, and also to attend on some affairs of a similar character at York. As soon as I had completed my engagement at Sheffield, I had to wait for more than two dreary hours in momentary expectation of the arrival of the coach that was to take me on to York. The coach had been delayed by a deep fall of snow, and was consequently late. When it arrived, I found that there was only one outside place vacant, so I mounted to my seat. It was a very dreary afternoon, and the snow was constantly falling. As we approached Barnsley, I observed, in the remaining murky light of the evening, the blaze of some ironwork furnaces near at hand. On inquiring whose works they were, I was informed that they belonged to Earl Fitzwilliam, and that they were under the management of a Mr. Hartop. The mention of his name, coupled with the sight of the ironworks, brought to my recollection a kind invitation which Mr. Hartop had given me while visiting my workshop in Manchester to order some machine tools, that if I ever happened to be in his neighborhood, he would be most happy to show me anything that was interesting about the ironworks and colliery machinery under his management. I at once decided to terminate my dreary ride on the top of the coach. I descended, and, with my small valise in hand, I trudged over some trackless, snow-covered fields, and made my way by the shortest cut towards the blazing iron furnaces." He was introduced to Mr. Hartop's wife and daughter Anne. Speaking of the latter Mr. Nasmyth says, "I soon perceived in her, most happily and attractively combined, all the conditions that I could hope for and desire to meet with in the dear partner of my existence." He proposed, and was accepted, and two years afterwards, on the 16th of June, 1840, they were married. "From that day to this," he adds, "the course of our united hearts and lives has continued to run on with steady, uninterrupted harmony and mutual happiness. Forty-two years of our married life find us the same affectionate and devoted 'cronies' that we were at the beginning, and there is every prospect that, under God's blessing, we shall continue so to the end."

It is not, however, in their loves that the great inventors have revealed the most romantic features of their lives.—*Romance of Invention.*

The Locomotive.

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NEW SERIES—VOL. XII. HARTFORD, CONN., MAY, 1891. No. 5.

Laminated Steel Plates.

In the February issue of the LOCOMOTIVE we illustrated a laminated steel plate that came to our notice some time ago. At the time we first received the plate it was generally believed that steel was not liable to blister, since it is rolled directly from the ingot, and should, therefore, be entirely sound. Within a year or two, however, several instances have come to our notice, in which steel plates have been badly laminated. The cuts given in this issue illustrate two such cases.

Fig. 2 shows a plate that was cut out of a steel boiler that had been in use only six weeks. A blister developed on the lower side of the second fire sheet. It was raised about three inches at the highest point, and as nearly as could be judged by the eye it covered an area about twenty inches square. On cutting it out, however, it was found that the lamination extended in a thin line so as to separate the plates over an area about thirty inches wide and thirty-six inches long, the plate being so evenly separated as to closely resemble two plates, laid one upon the other. This appearance is represented in

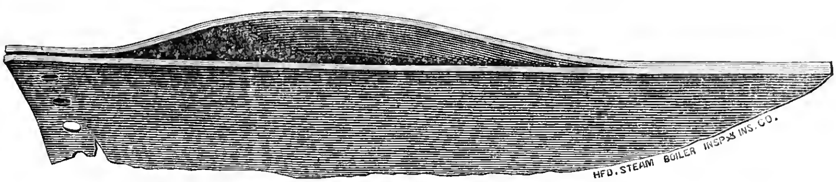


FIG. 1.—LAMINATED PLATE CUT FROM A STEEL BOILER.

the cut. The outer layer, being exposed to the fire, had bulged over part of its extent, while the inner half showed no change in form and was free from any scale or deposit. The workmanship on the boiler is first-class in every respect, and the material was evidently intended to be, as the brand of one of the best mills in the country is stamped *directly on the blister.*

Some correspondence passed between this office and the makers of the plate. A few extracts from it are appended. "We are very sorry," writes the manufacturer, "to learn of the lamination having occurred. It is not the result of any attempt to weld the steel, as some people suppose, but in casting the steel ingots bubble or blow holes will be confined in the mass sometimes, and, of course, when the ingot is rolled out, the surfaces are flattened together, leaving what appears like a blister, sometimes large, sometimes small. In the earlier days of steel making we found frequent cases of this kind, but in recent years skill and experience have enabled the steel men to largely overcome it. We watch constantly for it, however, in examining and hammering our steel plates, but in this case the surfaces were evidently so closely in contact that the hammer did not detect any flaw, either with us or with the inspector at the boiler shop; and it did not show up until the heat separated the surfaces."

The piece of plate was cut apart through the middle of the blister, as shown in Fig. 1, and one-half of it was sent to the maker for examination. He says: "The plate shows up very badly, and is certainly a very unusual specimen. In all our years of experience in the steel-plate business we have not seen its parallel; but we have seen defects of the same character, though much less extensive. It was caused, no doubt, by slag confined in the ingot. About nine years ago we bought some fire-box steel for a boiler for our own use, from a reputable manufacturer who sells a great deal of material throughout the New England States. Five plates out of the lot had to be rejected on account of blisters, and yet they were sold as the best open hearth fire-box steel. Such defects are likely to occur in the case of ingots poured from the top. It is now considered much better to pour from the bottom of the mold, through a pipe placed alongside and connected to the molds by underground channels. Our rolls are cast in the same way. The metal flows more freely, and without splashing; and any impurities contained in it will rise to the top more readily, and remain there." Again he says: "The case, we think, is the worst one that has ever escaped our hands; and we admit that to one acquainted with the difficulties in the manufacture of steel ingots it has the appearance of an attempt to weld steel together. In any case of this kind, however, the weld would gradually weaken and not come to a definite termination. One could readily satisfy himself on this point by cutting off a portion and splitting it back to the end of the fold, and noting how suddenly the solid metal begins."

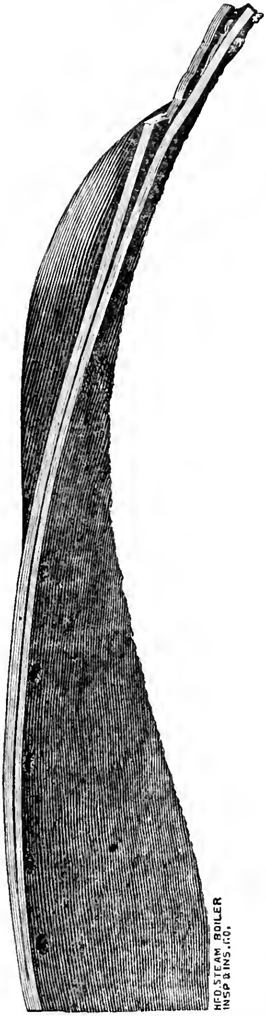


Fig. 2. — Laminated Steel Plate.

It is possible to leave too much of the top of the ingot, in cutting off the crop ends of the slabs intended for plates. If the plates are sheared too close to the edge of the plates as rolled, lamination may appear on the edge of the finished product. This does not seem sufficient, however, to explain such extensive internal separation as in the present specimen.

In Fig. 3 a very curious blister is shown. It occurred some time ago on a boiler that was supposed to be constructed of steel, though at the time, not having had any such experience, we had some doubts about it being steel. The singular feature about it is that it should have bulged so nearly equally in both directions. It has been suggested that a small fissure may have connected the original line of separation with the interior of the boiler, and that water penetrated the plate through this fissure, forcing the plates apart when it was afterwards turned into steam. This assumption looks reasonable, provided the fissure through which the water entered was very small, so that steam could not pass out of it rapidly. Very likely, if this explanation is correct, the blister was developed gradually, by the entrance of water every time the fires were drawn, and its subsequent evaporation when the fires were again started. In the original specimen numerous small blisters could be seen on the interior surfaces of the large one.

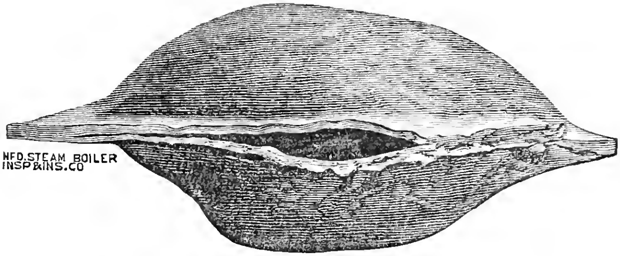


Fig. 3. — Curious Blister from a Steel (?) Boiler.

Inspectors' Reports.

January, 1891.

During this month our inspectors made 5,953 inspection trips, visited 12,513 boilers, inspected 4,577 both internally and externally, and subjected 521 to hydrostatic pressure. The whole number of defects reported reached 10,719, of which 925 were considered dangerous; 48 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	655	39
Cases of incrustation and scale,	1,161	49
Cases of internal grooving,	137	18
Cases of internal corrosion,	409	34
Cases of external corrosion,	736	59
Broken and loose braces and stays,	267	108
Settings defective,	292	34
Furnaces out of shape,	386	26
Fractured plates,	205	57
Burned plates,	183	36
Blistered plates,	244	17
Cases of defective riveting,	2,440	73
Defective heads,	108	21
Serious leakage around tube ends,	1,926	120
Serious leakage at seams,	437	45
Defective water-gauges,	390	62
Defective blow-offs,	123	40
Cases of deficiency of water,	18	8
Safety-valves overloaded,	75	15
Safety-valves defective in construction,	85	20
Pressure-gauges defective,	299	36
Boilers without pressure-gauges,	5	5
Unclassified defects,	138	3
Total,	10,719	925

February, 1891.

During this month our inspectors made 5,231 inspection trips, visited 9,484 boilers, inspected 3,296 both internally and externally, and subjected 618 to hydrostatic pressure. The whole number of defects reported reached 10,140, of which 677 were considered dangerous; 31 boilers were considered unsafe for further use. Our usual summary is appended:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	536	37
Cases of incrustation and scale,	902	36
Cases of internal grooving,	34	8
Cases of internal corrosion,	254	15
Cases of external corrosion,	722	61
Broken and loose braces and stays,	173	41
Settings defective,	172	18
Furnaces out of shape,	264	14
Fractured plates,	190	56
Burned plates,	219	46
Blistered plates,	163	8
Cases of defective riveting,	2,797	17
Defective heads,	43	9
Serious leakage around tube ends,	2,269	136
Serious leakage at seams,	424	22
Defective water-gauges,	318	27
Defective blow-offs,	106	40
Cases of deficiency of water,	24	13
Safety-valves overloaded,	76	16
Safety-valves defective in construction,	56	11
Pressure gauges defective,	289	32
Boilers without pressure gauges,	10	10
Unclassified defects,	99	4
Total,	10,140	677

Boiler Explosions.

March, 1891.

Colliery (48). Two boilers in a battery of thirty-two, at the Henry Clay Colliery, Shamokin, Pa., exploded on March 2d. Four firemen were at one end of the boiler-house, cleaning the fire, and had just vacated the spot when a terrible explosion followed. The boilers were located in the first set at the entrance to the building, and were blown in all directions. Two of them were lifted from their resting place, and hurled along the banks of the Reading Railroad, sixty feet distant. Six others were also dislodged. Samuel Hause and Daniel Horan, engineers, were struck by the flying debris, and seriously injured. Fitzgard, a water boy, was struck by a brick, and slightly injured. Two other employes were also hurt. The boiler-house is a complete wreck, and the loss is estimated at $20,000. The colliery was compelled to suspend work until the damage was repaired.

Furniture Factory (49). There was a great excitement for a while at the Fort

Wayne Furniture Company's factory, at the foot of Lafayette street, Fort Wayne, Ind., on March 2d. About 1 o'clock, just as engineer Frank Schrantz was going to start the machinery, the boiler exploded with terrific force, fearfully scalding Mr. Schrantz, who was standing immediately in front of it. The accident was caused by the giving way of a tube. Schrantz received the full force of the steam against his body and his face; hands and arms were badly scalded. The factory was closed until a new boiler could be put in.

Coal Mine (50). An explosion took place in the Shelburn Coal Mine, Shelburn, Ind., on March 4th. Three boilers used for furnishing steam for the air compressor, which ran the mining machines and hoisting engine, gave way, lifting the three boilers from their resting place, throwing fragments in every direction, completely demolishing the engine-room, and destroying everything in the direction in which the fragments traveled. Will Lloyd, Ernest Lloyd, Frank Montague, and "Dad" Wheatley, the mine boss, were in the engine-house when the explosion occurred, but all escaped without serious injury. The latter was hit with a flying brick. Five men were in the mine. They received no injury, and were hoisted out by hand.

Dye Works (51). James McCombe's dye works, on South Pearl street, Albany, N. Y., were blown up on March 4th. The boiler, which had been tested and pronounced safe, was hurled through the roof of the building and fell on a shed half a block away. McCombe and four of his five sons were playing euchre in the room over the boiler at the time. One boy was sent through a window, and escaped with slight bruises. The other three sons escaped with severe scalds and bruises, but the father had two ribs broken, and was also scalded. The entire building was wrecked, and caught fire. Adjoining buildings escaped with little damage. In the shed on which the boiler alighted were two little children playing, both of whom escaped as if by a miracle. "Chunks of the boiler smashed windows in the vicinity, and one piece broke up the dinner of the Van Appledorn family." The force of the explosion was felt for blocks around and led many to believe that there had been an earthquake. About $5,000 damage was done.

Traction Engine (52). Henry Ross, a prominent citizen and merchant of Marietta, Chickasaw Nation, I. T., was killed, on March 12th, by the explosion of a traction engine boiler. The engine was being moved along the road and Ross was riding on it when the explosion took place, blowing him some fifty feet and jamming his head into a bank of earth up to his shoulders. He died a few hours afterwards. One of the newspaper accounts says that "in crossing a mire he stalled with the engine and tried to increase the amount of steam. The steam indicator was out of order and would not show but 120 pounds of pressure."

Saw-mill (53). The boiler of a saw-mill in Diedrich, near Effingham, Ill., exploded on March 11th, killing Barney Beekman, William Weihenbach, and Garhardt Eils, young men employed in the mill.

Saw-mill (54). On March 12th, a terrible boiler explosion occurred at Rank's sawmill at Wayside, near De Pere, Wis., resulting in the death of Henry Nohr, the fatal injury of Charles Kruger, and the serious injury of others. The boiler, an old and defective one, was that morning cleansed by engineer Nohr and assistants, and found to contain a dangerous flaw. It was remedied as well as circumstances would permit, and Nohr, with careless bravado, said: "Let her go; I'll go with her." Between 10 and 11 o'clock the boiler burst, dashing one of its engines through the roof of the mill, scattering flues and scalding water broadcast, and badly wrecking the building. Nohr was discovered beneath a mass of debris, terribly scalded and mutilated, with life entirely extinct. Charles Kruger was covered with debris. He was terribly, and perhaps fatally, injured. Louis Gates, who stood on the saw carriage in the second story at the time, received a serious cut in the head, and was injured internally. Edward Mulloy was painfully injured by a blow from a flying boiler flue, and half a dozen other hands received painful scratches and bruises. The wrecked mill at once burst into flames, but the fire was promptly extinguished.

Saw-mill (55). An explosion occurred at Ellis Junction, Wis., at the Butte-Mueller saw-mill on March 16th. The boiler of the planing-mill blew up, hurling the engineer, Moritz Mursch, through the wall, and burying him to the neck in a mass of debris. Three other men, employes of the company, were injured by the explosion, Charles Wœrtzell, Will Manson, and Andrew Kinsler. Mursch was dug out from the mass of debris in which he was buried, and taken home. At last reports he was doing well. The accident was caused by a defective flue. The building was scattered in all directions, part of the roof being found across the Milwaukee & Northern Railroad track, 120 rods away. The damage is estimated at between $2,000 and $3,000.

Saw-mill (56). On March 21st, the large steam boiler in Benjamin Binegar's saw-mill at Albany, near Muncie, Ind., exploded, seriously injuring Eli Smith, who was in the mill at the time. Smith had an arm broken, and one shoulder dislocated, and received internal injuries that may prove fatal. A half dozen employes in the mill escaped with slight injuries. The damage will amount to about $200.

Steamboat (57). On March 21st, while near Savannah, Ga., the boiler of the steamer *Farmer*, of the Georgia & Florida railroad route, exploded. Six of the deck hands were scalded by the steam in their efforts to escape, and jumped overboard. Three men, — Jeff. Mill, William Anderson, and Stephen Harris — all colored, were drowned. Jack Watson, a colored fireman, is also missing. The other two were picked up by the steamer's boat along with F. Barrs, a white passenger, who jumped over in his fright. Captain White of the *Farmer* says that the crew were all down below at supper at the time, and that the steamer had just slowed down as she neared Doboy. The cargo of cotton caught fire, but little damage resulted.

Colton Mills (58). The Charleston cotton mills, in Drake street, Charleston, S. C., were the scene of a terrific explosion on March 23d, by which Mildredge Dorne, a night fireman, was blown through a window of the building. He struck a fence outside, and was picked up unconscious from a fracture of the skull and other injuries.

Brick Yard (59). At 10 o'clock A. M., on March 27th, a boiler explosion at Williams & Co's new brick yard, at Marion station, near Pittsburgh, Pa., on the B. & O. R. R., resulting in the death of Engineer John Jones, aged 25 years. Jones was not killed outright. He was taken to the Homœopathic hospital, but expired a few moments after his arrival.

Colliery (60). On March 28th, three boilers at the Delaware & Hudson Canal Company's "Grassy Island" colliery near Scranton, Pa., exploded with terrific force, almost instantly killing one of the firemen, Joseph McGovern, slightly injuring another, Patrick McCawley, and blowing two buildings into fragments. The shock was felt for miles. One of the boilers weighing several tons was hurled fully five hundred feet across the D. & H. tracks and imbedded in a culm heap, while another was thrown in a westerly direction about one hundred feet to the gravity track. The fireman who was killed was blown fully thirty feet, striking against a heavy timber, where he was found unconscious. He died in a short time without regaining his senses. A few minutes before the accident the two firemen were conversing in the engine-room. McGovern left his companion and went into the fire-room, and, according to the story of McCawley, he had hardly any time to do anything before the crash came. The nest contained nine boilers, only three of which burst. The fire-house was entirely destroyed, the engine-house was badly wrecked, and two large iron stacks were blown down. McCawley was struck by a flying missile, and injured, but he was able to walk home. Company officials say that the boilers of Grassy Island Colliery were believed to be perfectly safe. The oldest had not been up over seven years, some were put in four years ago, and one was set only a month ago.

Grist Mill (61). Captain C. W. Ennis's grist mill, near Milledgeville, Ga., exploded on March 30th. Mr. Charles Ennis, the oldest son of the owner of the mill, was buried under the wreck and killed. The end of the mill-house was torn into shreds, and adjoining property was more or less damaged. A piece of the boiler, estimated as weighing 1,000 pounds, was blown over the Milledgeville fertilizer works, more than 200 yards away. Another piece of iron crashed through the roof and floor of the oil house. A brick was blown through a car-box 100 yards away, and a stray piece of iron tore up the roofing on the depot, fifty yards off. The cause of the explosion is not definitely known, but is thought to have been a defect in the boiler. At the time of the explosion the boiler had two gauges of water, and only sixty pounds of steam. Young Ennis had stopped running to raise more steam, and was in the act of oiling up when the explosion occurred. When the engine stopped, the mill hands all went out to see an approaching train, so none of them were injured.

Tobacco.

Dr. Seaver of Yale College is waging war upon the habit of tobacco smoking, which some of the students there indulge in. He is the physician of the college and the professor of athletics, a man of science who follows scientific methods in any investigation he may undertake. He has been engaged for eight years in observing the effects of tobacco smoking upon the bodies and minds of the Yale students, and he has just published a remarkable budget of statistics.

Dr. Seaver informs the public that the students of Yale who indulge in tobacco smoking are inferior in physical vigor and mental ability to those who do not. According to his reckoning, the smokers have less lung power than the anti-smokers; they have less chest-inflating capacity; they are of less bodily weight, and they are even of less height. The muscular and nervous power of the smoking students is notably and noticeably less than that of the anti-smoking. From an athletic point of view, therefore, the Yale professor of athletics considers himself justified in waging war upon the tobacco habit.

Not only in a physical way, but also in an intellectual way, the Yale smokers are inferior to the anti-smokers. The smoking habit is disadvantageous to scholarship. Of those students who, within a given time, have received junior appointments above dissertations, only five per cent. were smokers, and very few smokers received appointments of any kind. It would seem, therefore, that the brain power and the scholarship of the smokers at Yale are far inferior to those of the anti-smokers.

The demonstrations of Dr. Seaver appear to be influencing the Yale mind. He is able to report that seventy per cent. of the senior class in the college do not smoke, that the leading athletes do not smoke, and that not a single candidate for the rowing crew is a smoker.

Young America, athletic, intellectual, and ethical, can ruminate upon the Yale statistics collected by Dr. Seaver. —*New York Sun.*

The Locomotive.

HARTFORD, MAY 15, 1891.

J. M. Allen, *Editor.* A. D. Risteen, *Associate Editor.*

The Locomotive *can be obtained free by calling at any of the company's agencies.*

Subscription price 50 cents per year when mailed from this office.

Bound volumes one dollar each. (Any volume can be supplied.)

Papers that borrow cuts from us will do us a favor if they will plainly mark them in returning, so that we may give proper credit on our books.

The work of the Ohio Mechanics' Institute for the past year is well set forth in the sixty-third annual report of the board of directors, which lies before us.

The twentieth annual report of the *Schlesischer Verein* for the inspection of steam boilers is at hand, and also the eighteenth report of the *Sächsisch-Thüringischer Verein.* Both reports contain much interesting matter.

Chief Engineer Sinigaglia, of the *Associazione fra gli Utenti di Caldare a Vapore* (Naples) sends us the constitution of the association he represents, which was organized by decree of King Humbert on Nov. 16, 1890.

We have received a very neat and tasty "tire and axle" paper weight from the Midvale Steel Company, of Philadelphia. This company turns out steel castings and forgings of all kinds, including the very heaviest; and for the past nine years it has furnished ordnance material to the United States Government.

The fourth annual convention of the American Boiler Manufacturers' Association met at St. Louis on May 12th. As we go to press, we have had no word from the convention, but we do not doubt that all the members had a pleasant and profitable time.

Mr. C. J. H. Woodbury, chairman, has kindly remembered us with a copy of the report of the sub-committee on sanitation, to the school committee of the city of Lynn, Mass. This report should be read by every school committeeman in the land. The results obtained by Mr. Woodbury and his colleagues may be inferred from the following tests made in one of the remodeled rooms. "Room No. 1, Center School, Lynn, Mass., 9.30 A. M., Jan. 12, 1891. Temperature outside, 40°. Humidity of air, saturation (just after a long rain), wind northeast, and velocity barely perceptible. Temperatures in room — middle of floor, 69°; four feet from floor, 71°. These temperatures were the same in different parts of the room at the desks. Temperature against partition wall, three feet from the floor, 70°. Incoming air over jacket stove, seven feet above the floor, 75°; temperature of outgoing air at ventilator, 71°. No appreciable heat radiated from the jackets around the stoves. No observable motion of air in the room. Appearance of pupils healthy; eyes bright; no tendency to irritation and disorder. Ventilation 3,060 cubic feet per hour to each pupil." Tests of the amount of carbonic acid gas present gave 6 to 8 parts per 10,000 parts of air; whereas, before the change in ventilating arrangements, the amount of carbonic acid gas varied from 12.6 parts to 29.1 parts per 10,000 parts of air.

Valuable suggestions are also made in regard to the outhouses, and the present system adopted at Lynn is illustrated by several excellent cuts. Mr. Woodbury is to be congratulated upon the results his committee can show.

Obituary.

It becomes our sad duty to record the deaths of two more of the general agents of this company.

Mr. John L. Smith, of Providence, R. I., who passed away on March 19th, was appointed agent of this company shortly after its organization, and continued active in its service until stricken down by a fatal sickness some two years ago. He was a man widely respected for his unswerving integrity. He was faithful in all places where responsibility was laid upon him, and he had the respect and confidence of all who knew him.

Mr. George P. Burwell, general agent for northern Ohio, died on April 12th. Mr. Burwell was one of the pioneers of northern Ohio. In early life he was extensively engaged in building operations, and his work may be seen in a number of the cities of that part of the State. Later in life he became the agent of several fire insurance companies, and a few years after the organization of the Hartford Steam Boiler Inspection and Insurance Company he was appointed its general agent. He was a man upright in all his dealings, and faithful to the interests intrusted to his care. He had the respect and confidence of the officers of this company, and of his associates in the insurance business. He had passed the limit of three score years and ten, but up to the time of his last sickness he had the vitality and business discernment of a man much younger in years.

In Indiana, some little time ago, there was an exhibition of heroism by an engineer. which should not pass unnoticed. An engine attached to a Chicago & Erie freight train broke down at West Point, Ind., and engine No. 69, Edward Murphy, engineer, and George Kirby, fireman, was sent out from Huntington, Ind., to take the train to Chicago. When in a deep cut the boiler of No. 69 exploded. The front head was blown 400 feet up the track. The wreck of the engine ran about 700 feet before coming to a stop. Murphy was badly scalded and had one leg broken, and Kirby was very badly scalded. Vestibule train No. 8 was about due, and engineer Murphy's first thought was of this. Wounded as he was, he seized a red lantern, and crawled up the track, dragging his broken leg. After covering several hundred yards, he met a farmer, to whom he gave the lantern and who signaled the fast express just in time to prevent a collison.

In our December issue we said that "engineer Murphy was killed, and his fireman fatally injured." According to the brief account we had then received, this was the fact; and we are glad to make the correction, and to commend Mr. Murphy for his noble conduct.

On the Strains in Trusses.

In steam-engineering practice trusses sometimes have to be designed to support steam pipes and boiler-house roofs. There is usually no difficulty in selecting the kind of truss desired; but when it comes to calculating the strains on the different parts of the truss, most engineers have to fall back on Rankine and Trautwine. Of course, the methods that these writers give are sound and accurate; but it would be preferable for the draughtsman to have some easily understood *graphical* method, so that the strain on each piece could be found without much calculation. Such a method is given below. We do not claim it to be new, but we have seen very little about it in print.

For the sake of thoroughness, let us begin with fundamental principles.

A strain or any other force is represented on the drawing board by a straight line, the direction of which shows the direction of the force, and the length of which shows the intensity or magnitude of the force. For example, suppose a small body, A in Fig. 1, is acted on by a force of 2,000 pounds, which tends to pull it horizontally to the right. Then this force would be represented by the straight line AB. If the scale of the drawing were one inch to each thousand pounds, AB would be two inches long.

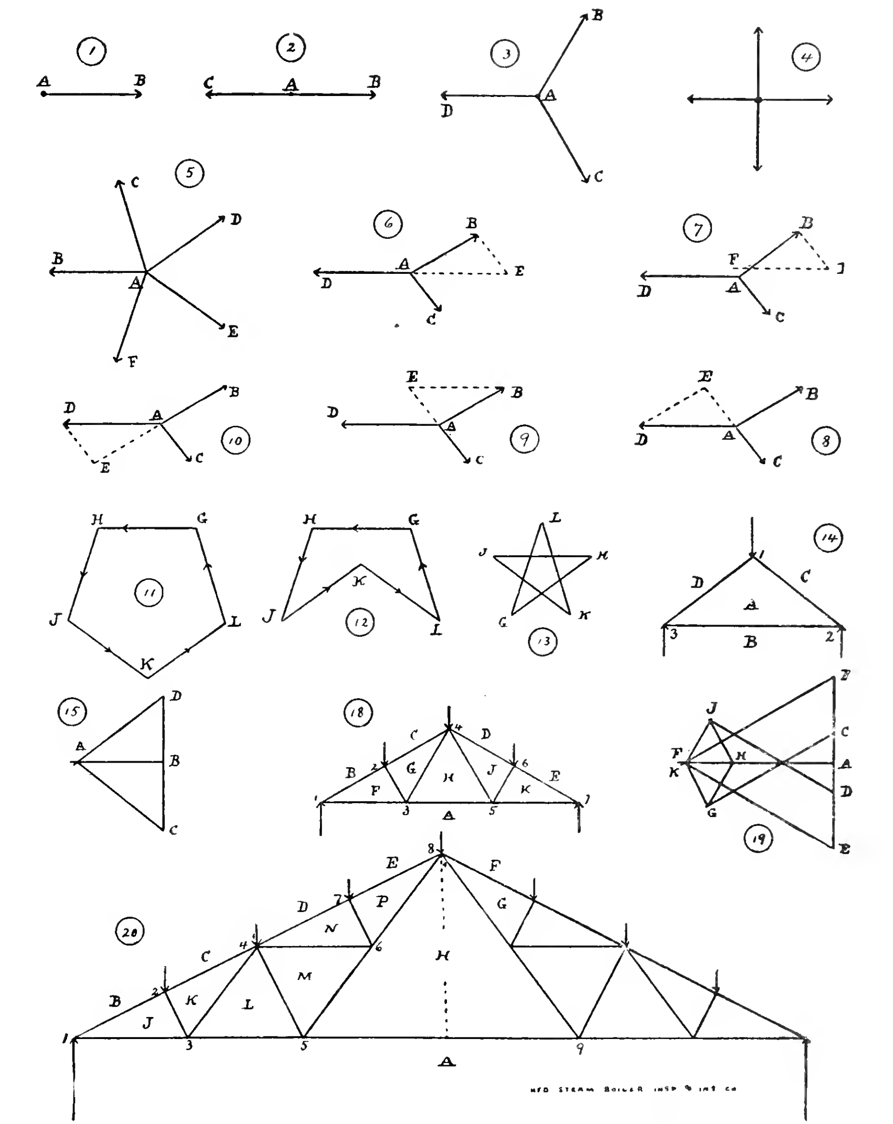
Any number of forces may act upon a body at the same time. Thus in Fig. 2 the point A is acted on by a force AB that tends to pull it to the right, and, at the same time, by an equal but opposite force, AC, that tends to pull it to the left. The two forces being equal and opposite, the body A will not stir.

It is not necessary, in order to produce equilibrium, that the forces should be opposite in direction. In Fig. 3, for example, the body A is acted upon by three equal forces, AB, AC, AD, which are inclined to one another at an angle of 120°. In Figs. 4 and 5 a similar condition is seen. In all these cases it follows from the equality of the forces and the symmetry of their arrangement that the point A is in equilibrium. Any reason that could be advanced to show that A would move to the right, for example, in Fig. 3, could be applied, equally well, to show that it would move upward and to the left in a direction opposite to AC, or downward and to the left, in a direction opposite to AB.

In the examples given thus far, all the forces have been supposed to be equal; but this is by no means necessary, in order that equilibrium may exist. In Fig. 6 three unequal forces are shown, which exactly balance one another and leave the body A in equilibrium. The only condition that must be fulfilled in order that a body acted upon by three forces shall be in equilibrium is, that the lines representing the forces shall be capable of forming a perfect triangle without changing their directions.* Thus in Fig. 6 let us draw BE, equal and parallel to AC. Then if the forces are in equilibrium, EA must be exactly equal to AD, and must have precisely the same direction as AD. In Fig. 7 the same three forces are shown, except that the *direction* of AB has been changed slightly. As before, draw BE parallel and equal to AC, and then draw EF parallel and equal to AD. Here we find that the three lines AB, AC, AD, are not capable of forming a perfect triangle, unless the *direction* of one or more of them be changed. The forces in Fig. 6 may be shown to be in equilibrium in a variety of ways. In Fig. 8, for example, draw DE equal and parallel to AB; then AE must be equal and opposite to AC. In Fig. 9 draw BE parallel and equal to AD; then AE must be equal and opposite to AC. In Fig. 10 another way is indicated, and still other ways are possible. In fact,

* See cautionary note on p. 76

the order in which the lines are taken makes no difference whatever, so long as they are capable of forming a perfect triangle, without changing their directions.



FIGURES ILLUSTRATING STRAINS IN TRUSSES.

When more than three forces are acting upon a body, they will be in equilibrium, and the body will remain at rest, *provided* a perfect polygon can be formed out of the lines representing the forces, in the same way that a perfect triangle was formed out of three forces in equilibrium. Let us take Fig. 5 as an example. Select a point *G* (Fig. 11), and through it draw *GH*, equal and parallel to *AB* in Fig. 5. Through *H* draw

HJ equal and parallel to AF. Through J draw JK equal and parallel to AE. Through K draw KL equal and parallel to AD. Finally, through L draw a line equal and parallel to AC. If this brings us back to where we started from (as it does in this case) the forces acting on A are in equilibrium. The polygon may be drawn in a great variety of ways, one of which is shown in Fig. 12, which was obtained as follows: Select some point, G, to start from. Then draw GH equal and parallel to AB, HJ equal and parallel to AF, JK equal and parallel to AD, KL equal and parallel to AE, and through L draw a line equal and parallel to AC. This brings us back to our starting point, and hence the five forces shown in Fig. 5 are in equilibrium. Still another way is shown in Fig. 13. Through the starting point G draw GH equal and parallel to AD; through H draw HJ equal and parallel to AB; through J draw JK equal and parallel to AE; through K draw KL equal and parallel to AC; and through L draw a line equal and parallel to AF. This brings us back to the starting point, as before, showing once more that the forces in Fig. 5 are in equilibrium.*

We are now ready to examine trusses, the simplest of which is shown in Fig. 14. This truss consists of three pieces, the load being supported from the apex, as indicated by the upper arrow. The piers at the two ends support the truss and its load. When the truss is in position, it presses down upon the piers at the ends, so that the effect *on the truss* is the same as though there was an upward thrust against it at each end, as shown by the lower arrows. In examining a loaded truss, the first thing to do is to draw what is called the "line of loads." In the present case there is only one load; namely, that which is suspended from the apex. We draw a vertical line DC (Fig. 15), therefore, which will represent this load on some convenient scale. It will be noticed that the truss is not lettered at the corners or joints, but that the letters are placed in the spaces and around the outside. This method of lettering possesses great advantages, as will be seen by comparing it with other methods in use. (Small figures have been placed at the corners in order to make the explanation of the letters simpler.) The force acting downward at 1 is called DC. The upper thrust of the pier at the right is called CB. The upper thrust of the pier at the left is called BD. The strain on the piece 1, 2 is called AC. The strain on 1, 3 is called AD. The strain on 3, 2 is called AB. The system ought now to be plain. *In naming a force, give the two letters that it lies between.* The load at the apex of the truss, when expressed in this way, is DC. Hence the vertical line that represents it in Fig. 15 is marked D at one end and C at the other. In the force-diagram that we are about to draw, therefore, the forces are denoted by a letter at each *end;* while in the truss-diagram the forces are denoted by a letter on each *side.*

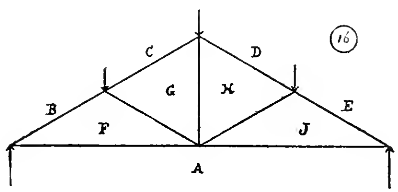
This much being done, we next draw CB in Fig. 15, equal and parallel to CB in Fig. 14: and then we draw a line upward from B in Fig. 15, equal and parallel to BD in Fig. 14. This brings us back to D, which was our starting point; for $CB = BD = \frac{1}{2} DC$. (It happens that these three lines lie on top of one another, but that makes no difference. The fact we just get back to the starting point shows that the supporting forces and the load are just equal.)

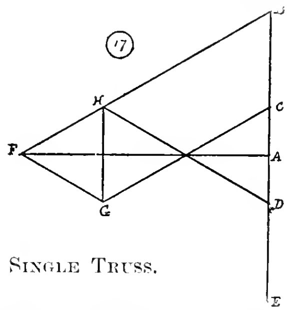
Now, let us examine the forces acting at 3 in Fig. 14. First, there is the supporting force of the pier, BD. Second, there is the oblique force DA, acting along the strut 1, 3. Third, there is the horizontal force AB, acting along the bottom chord. Since the truss is to stay where it is, these three forces must be in equilibrium, and must be capable of

*In this kind of work one very important thing must be kept in mind. The direction of the force is always to be marked by a small arrow-head; and care must be taken, in drawing the polygon or triangle, to draw every line, not only *parallel* to the given force, but *in the direction in which the arrow-head points.* If attention is not paid to this, great confusion will result.

forming a perfect triangle. We have already drawn the force BD on our diagram (Fig. 15). Through B in Fig. 15, then, let us draw a line parallel to BA in Fig. 14. We don't yet know where the point A will come on this line, because we don't know the magnitude of the force BA. Next, let us draw a line through D in Fig. 15, parallel to DA in Fig. 14. The point A must be on each of the two lines we have just drawn, and therefore it is at their intersection. Hence BDA, in Fig. 15, is the triangle of forces for the point 3 in Fig. 14; and since BD in Fig. 15 is drawn to scale, we can at once measure off, on the same scale, the forces DA and AB that act along 1, 3 and 2, 3 respectively. By following the triangle BDA around in the proper direction, we can also learn whether any given force is thrust or tension. The fact that BD is an *upward* force shows us that we must go around the triangle BDA in the order B to D, D to A, A to B, and *not the other way*. The force DA therefore acts on the point 3 obliquely downward; hence it is a *thrust*, and the piece 1, 3 must be a strut, adapted to bear *compression*. Also, still following the triangle around, the force AB acts on 3, so as to pull it to the right; hence it is a *pull*, and the piece 3, 2 must be adapted to resist *tension*. The strain on 1, 2 may be obtained in a similar manner, by joining A and C in the diagram. It is, of course, equal in magnitude to AD.

Let us now examine Fig. 16, which shows a simple truss with loads at three points instead of one. The same system of lettering will be followed: EA is the right hand





FIGS. 16 AND 17.—ANALYSIS OF A SINGLE TRUSS.

supporting force, and AB the left hand supporting force. Together these make up the vertical line EAB in Fig. 17. From B we lay off $BC = \frac{1}{3}(EA + AB)$, and from C we lay off $CD = BC = DE$. Our line of loads is now complete. First we will examine the forces acting at the left hand support. Through A in Fig. 17 draw a line parallel to AF, and through B draw a line parallel to BF. Mark the intersection F: the triangle ABF is the triangle of forces for the joint under consideration, and AF (tension) and BF (compression) may be measured off to scale. Next, let us pass up to the next joint above. Here we have the forces BC, CG, GF, and FB. In the diagram we already have BC, so through C we draw a line parallel to CG, and through F we draw a line parallel to FG. Mark the intersection of these lines G. Then $BCGFB$ is the polygon of forces for the point in question, and CG (compression) and GF (compression) may be measured off to scale.

Let us now examine the forces at the highest point. There are four of them,—CD, DH, HG, GC. We already have CD, so through D we draw a line parallel to DH, and through G we draw a line parallel to GH. The intersection of these is H, and the polygon of forces for the point under examination is $CDHGC$, and we may measure off DH (compression), HG (tension), and GC (compression). In a similar manner the forces acting at the remaining joints may be found. They will, of course, be equal to the corresponding forces on the other side of the truss. If the reader completes the diagram, he will find that J will coincide with F. The point should be numbered with both letters, and no confusion will result.

In Fig. 18 another truss is shown, the analysis of which is given in Fig. 19. After drawing the line of loads as usual, draw $ABFA$, the triangle of forces for the point 1. FA is tension and BF is compression. Next, take 2. Through C draw a line parallel to 2, 4, and through F draw a line parallel to 2, 3. Then $BCGFB$ is the polygon of forces for 2: CG is compression, and GF is compression. Next, examine the forces at 3. Through G draw a line parallel to 4, 3, and through A draw a line parallel to 3, 5. The intersection of these is H, and the polygon for 3 is AF (tension), FG (compression), GH (tension), HA (tension). Next, take 4. Through D draw a line parallel to 4, 6, and through H draw a line parallel to 4, 5. The polygon for 4 is CD, DJ (compression), JH (tension), HG (tension), GC (compression). Joints 5, 6, and 7 may now be examined, if desired; but the strains on the right-hand side of the truss will, of course, be equal to the corresponding strains on the left-hand side.

In Fig. 20 a Fink truss is shown, which is very satisfactory for most work that comes up in steam-engineering practice. This truss is of interest not only on account of its utility, but because a peculiar point arises in analyzing the strains in it. The loads come on seven joints, and the diagram is given in Fig. 21. After drawing the line of loads, let us begin with the joint marked 1. The three forces acting on this joint are AB, BJ, JA. Through A in the diagram draw a line parallel to 1, 3, and through B draw a line parallel to 1, 2. Mark the intersection of these J. Then $JABJ$ is the triangle of forces for the joint 1, and BJ (compression) and JA (tension) may be read off to scale. Next, let us take the joint 2. We already know the forces JB and BC, so we draw a line through C parallel to 2, 4, and another through J parallel to 2, 3. The intersection of these is K, and $JBCKJ$ is the polygon of forces for joint 2, and CK (compression) and KJ (compression) may be read off to scale. Let us next take joint 3. The only forces we do not know here are KL and LA. Through K we draw a line parallel to 3, 4, and through A we draw another parallel to 3, 5. (This last line is already drawn.) The intersection of these is L, and the polygon of forces for 3 is AJ (tension), JK (compression), KL (tension), LA (tension).

If the attempt is now made to analyze the forces acting on joints 4, 5, 6, 7, or 8, it will be found that the analysis presents difficulties of a peculiar nature. In all the joints we have thus far examined there were but *two* unknown forces acting. In the cases of the joints mentioned above there are *three* or more as yet unknown forces acting, and the problem appears indeterminate. It is not indeterminate, however, as a careful perusal of the following paragraph will show:

Let us examine joint 4. We already have three lines of the polygon for this point, namely, LK, KC, CD. Through D let us draw a line, DZ, parallel to 4, 7. The point N must be somewhere on this line. Let us assume it to be at n. Then through n we draw a line parallel to 4, 6, and through L we draw a line parallel to 4, 5. Then if we have guessed the position of n correctly, the intersection of these last two lines will be M. It is not likely that we have guessed the position of n correctly, so, instead of calling the last intersection M, let us call it m. Then if m and n were correct, the polygon of forces for the joint 4 would be CD, Dn (compression), nm (tension), mL (compression), LK (tension), KC (compression). Assuming for the moment that everything is correct up to this point, let us proceed to examine the forces acting at 5. We already have AL and Lm, and the only others are mH and HA. Through m draw a line parallel to 5, 6, and through A draw a line parallel to 5, 9. (This line is already drawn.) Mark the intersection h. Then AL (tension), Lm (compression), mh (tension), and hA (tension) constitute the polygon of forces for 5. Still assuming the foregoing to be correct, although it all rests upon the assumption that n is located properly, let us pass on to the consideration of joint 6. We have hm and mn, so through n we draw a line parallel to 6, 7, and through h we draw another parallel to 6, 8. The intersection of these is p, and the polygon of forces for 6 is hm (tension), mn (tension), np (compression), and ph (tension). Now, let us examine joint 7. We have pn, nD, and DE, so through E we draw a line parallel to 7, 8, and it ought to intersect np at p, the polygon of forces for 7 being pn, nD, DE, Ep. Since this procedure does not bring us back to p again, it follows that our original assumption in regard to n was not correct; and our next undertaking must be to find the true position of n. This true position must be such that the point p will lie on the line EW. We cannot change the *direction* of any line in the diagram, because that is determined by the direction of the corresponding line (or force) in the truss. Hence, after we have made the correction, every new line must be parallel to its present position; and the triangle nmp, which is now nearly equilateral, with its upper side horizontal, must remain of the same shape, and still have its upper side horizontal. We have, therefore, simply to draw a similar triangle in such a manner that one of its corners shall lie upon each of the lines DZ, LY, and EW. It will be of assistance to note that JKL is just such a triangle as we require, being of precisely the same shape as nmp, and having one of its corners on each of the lines BJ, CX, LY. The simplest way to construct the triangle we want, then, is to continue the line JK till it cuts DZ at N, and EW at P. Then draw NM horizontally till it intersects LY at M, and join P and M and continue the line PM up to H. The diagram of the left-hand end of the truss is now complete, and the strains may be measured off to scale. The polygon for 4 is CD, DN, NM, ML, LK, KC. The polygon for 5 is AL, LM, MH, HA. The polygon for 6 is HM, MN, NP, PH. The polygon for 7 is DE, EP, PN, ND.

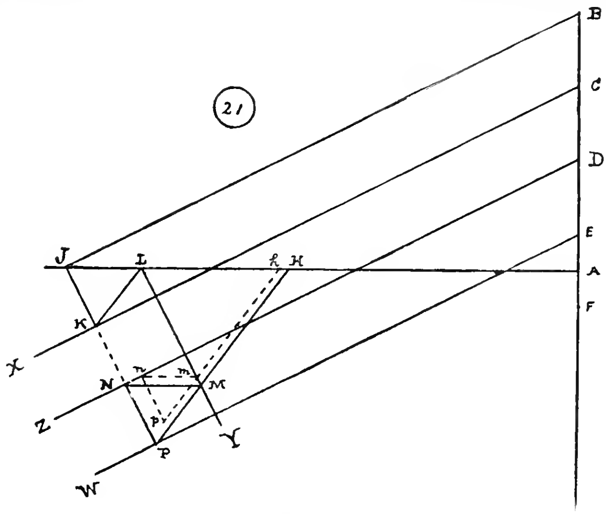


Fig. 21. — Analysis of Fig. 20.

The dotted vertical line in Fig. 20 represents a rod to support the weight of the tie-rod 5, 9. *It is not an essential part of the truss*, like the vertical rod in Fig. 16, and hence it may be omitted in considering the strains in the truss that are produced by the load. In all cases care should be taken to omit such non-essential parts, in finding the stresses graphically, or confusion is likely to result.

The present article being unusually long, we have not attempted to explain the manner of distributing the loads to the several joints, nor have we considered the effect of unequal loads. We are seldom called upon to design trusses for anything but roofs and steam mains, and in the case of roofs the load may be considered uniform and equal to the weight of the roof and truss, together with such snow as may lodge upon the roof in the winter. Nor have we attempted to explain the selection of suitable pieces for the various parts of the truss. — A. D. R.

The Locomotive.

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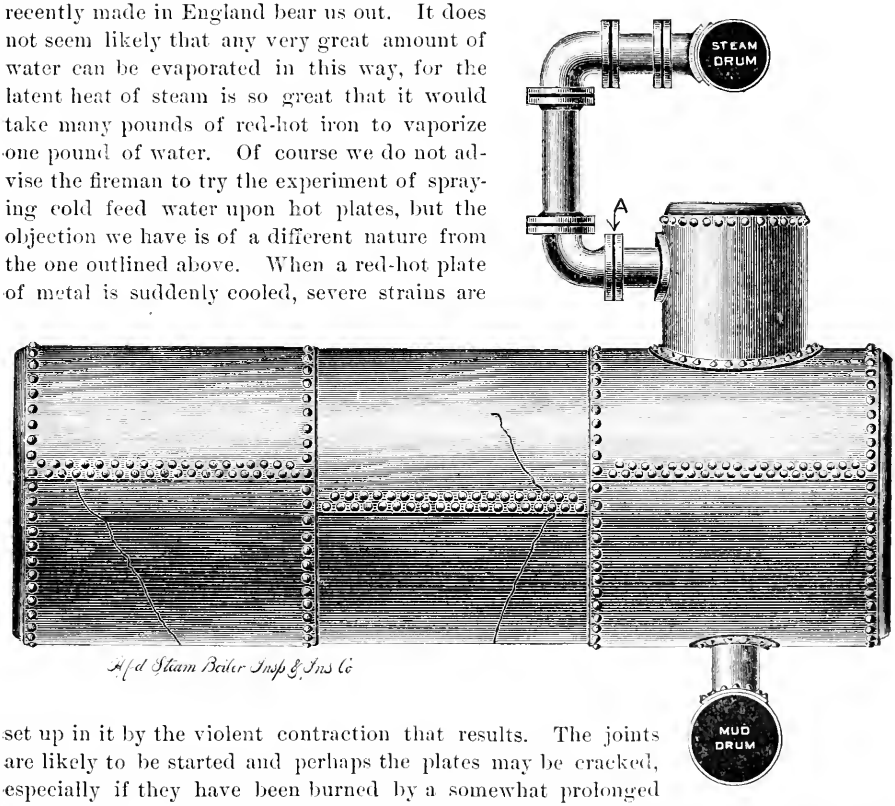
NEW SERIES—VOL. XII. HARTFORD, CONN., JUNE, 1891. No. 6.

A Curious Boiler Explosion.

When a boiler explosion occurs, there are two things that the public thinks of at once. In the first place, they are apt to feel pretty sure that the water was very low, and that the fireman turned the feed on suddenly, and that when it came in contact with the over-heated plates and tubes a tremendous body of steam was instantly generated, and a disastrous explosion was the result. We have often expressed our opinion concerning this kind of explosion, and experiments recently made in England bear us out. It does not seem likely that any very great amount of water can be evaporated in this way, for the latent heat of steam is so great that it would take many pounds of red-hot iron to vaporize one pound of water. Of course we do not advise the fireman to try the experiment of spraying cold feed water upon hot plates, but the objection we have is of a different nature from the one outlined above. When a red-hot plate of metal is suddenly cooled, severe strains are



set up in it by the violent contraction that results. The joints are likely to be started and perhaps the plates may be cracked, especially if they have been burned by a somewhat prolonged overheating. In this way, the boiler may be materially weakened so that it is not safe to run it at the ordinary pressure, and an explosion may result.

When low water cannot be assigned as a cause, the public usually concludes that some mysterious agency has been at work — something never yet identified and perhaps not yet suspected. In the present issue two theories of such action are proposed, with what probability of truth we leave it to our readers to decide.

Now we have no wish to check the progress of discovery in this or in any other direction, and if any hitherto unrecognized cause of explosion can be shown by experiment to exist, we shall be pleased to look into it and shall endeavor to devise a means of avoiding it. Having had some twenty two years of experience in such matters, however, during which time we have carefully investigated a large number of explosions, we must say that no case has ever come to our notice where it was necessary to assume unknown forces to be at work. In fact, the wonder is, not that so *many* boilers explode, but that so *few* of them explode.

A number of cases have come to our notice in which boilers have exploded during the night or at other times when there was (presumably) little or no fire under them. In every instance of this kind where we have been able to make an investigation, some satisfactory and sufficient cause has been found; and we believe that some well-known cause could be found in *every* case.

The cut accompanying this article represents a boiler that exploded a short time ago from a curious cause. It was one of a battery of four. It was 12 feet long and 48 inches in diameter with a dome 24 inches in diameter and 24 inches high. Shell was of steel, double riveted, $\frac{1}{4}$ inch thick. There were 54 tubes each 12 feet long and 3 inches in diameter. There was also a 12-inch steam drum and a 16 inch mud drum. Steam was taken from the side of the dome as shown in the cut. In connecting the steam pipe to the dome, the engineer used a stout rubber gasket at *A*, which he trimmed neatly around the outside of the flange. He forgot, however, to cut a hole through it for steam to pass through. If the full boiler pressure had acted on the blind gasket, it would probably have bulged it out and burst it, forcing a way out for itself; but under the circumstances the *effective* pressure on the gasket was only the *difference* between the pressure in this boiler and that in the others. Even then, it hardly seems as though the rubber would be strong enough to allow the pressure to run up to the bursting point, but it was strong enough, for it was afterwards found unbroken; and the boiler blew up and did over a thousand dollars worth of damage. The course of the fractures is indicated in the cut. Fortunately, nobody was hurt.

Inspectors' Reports.

MARCH, 1891.

During this month our inspectors made 6,086 inspection trips, visited 12,195 boilers, inspected 4,389 both internally and externally, and subjected 780 to hydrostatic pressure. The whole number of defects reported reached 11,227, of which 903 were considered dangerous; 51 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	639	23
Cases of incrustation and scale,	1,146	32
Cases of internal grooving,	72	13
Cases of internal corrosion,	398	37
Cases of external corrosion,	708	37
Broken and loose braces and stays,	110	24
Settings defective,	276	16

Nature of Defects.	Whole Number.	Dangerous.
Furnaces out of shape,	357	22
Fractured plates,	204	68
Burned plates,	173	23
Blistered plates,	234	11
Cases of defective riveting,	2,728	159
Defective heads,	64	12
Serious leakage around tube ends,	2,566	206
Serious leakage at seams,	387	34
Defective water-gauges,	364	29
Defective blow-offs,	141	28
Cases of deficiency of water,	11	9
Safety-valves overloaded,	55	13
Safety-valves defective in construction,	102	32
Pressure-gauges defective,	331	45
Boilers without pressure-gauges,	3	3
Unclassified defects,	158	27
Total,	11,227	903

Boiler Explosions.

APRIL, 1891.

ELEVATOR (62). On April 8th, the Diamond Elevator, at Eighth street and Central Ave., Minneapolis, Minn., was destroyed by fire, together with its contents. It is said that the fire originated in the boiler-house by the explosion of one of the boilers and the consequent scattering the live coals in the furnace. It is certain that an explosion of some kind took place, though it might have been a dust explosion. Mr. Tournie, the head bookkeeper, says he heard an explosion, and that immediately the office door leading into the elevator was blown open with great force. He had barely time to lock the books and papers in the vault before the room was filled with smoke. A Mr. Olsen was seriously burned.

NAVY YARD (63). A serious accident occurred in the boiler-house of the Ordnance shop in the Washington Navy Yard on April 11th. Some trouble occurred to a 14-inch expansion joint over the boilers, and while a workman (Mr. Hardiston) was tightening the bolts under the command of Lieutenant Commander Pendleton, the joint broke; Hardiston and Pendleton were both struck by fragments of metal; the former dangerously, and the latter painfully, injured. There is no engineer attached to these shops. It is never safe to do work like this when the pipes are under pressure. Many serious accidents have resulted from it.

LOCOMOTIVE (64). A train collision occurred on April 13th, at Starbuck, Wash., resulting in the destruction of an engine and two cars. A freight train eastbound was standing at the Starbuck depot, and it was crashed into by a runaway engine, to which were attached two cars and a caboose. The runaway exploded, setting fire to the cars attached, which were totally consumed. When the caboose was burning, it was with the greatest difficulty that the Starbuck Hotel was prevented from burning down. No one was injured in the collision.

PLANING MILL (65). A terrific explosion occurred on April 16th, in the Lebanon Manufacturing Establishment, Lebanon, Ind. William Campbell, ex-county recorder, was acting as engineer, and was instantly killed. William Stewart, one of the members of the firm, was fatally injured. The works were entirely demolished. Flying debris landed 200 yards away.

PHARMACEUTICAL BOILER (66). The boiler in a shanty used by Silas Fleming in Steubenville, O., to make medicine and extract the juices of herbs, exploded with terrific force on April 17th, wrecking the shanty. Pieces of the boiler, brick, and boards were thrown 200 feet. All the windows of six houses on Dougherty terrace, fifty feet away, were broken. No one was killed.

LOCOMOTIVE (67). On April 20th, a locomotive exploded on the New Jersey & New York railroad, near Nyack, N. Y. The seven o'clock express train had stopped at Spring Valley, as usual, and shortly after starting again the explosion took place, filling the air with steam, ashes, and flying fragments. The account says that "those who were standing by waited breathlessly to see the mangled remains of unfortunate victims flying through the air." Happily they were disappointed, for no one was hurt. "The sentiment of the people seems to be," continues our account, "that the N. J. & N. Y. R. R. needs some new engines."

EXCELSIOR WORKS (68). The boiler at the excelsior works cooper shops of Philip Klein, in the center of the city of Evansville, Ind., exploded on April 22d, at 6 o'clock, causing damage to the amount of $1,000. The boiler itself tore through the building, and was only stopped by the heavy timbers in the front end. The front head of the boiler was blown across the street, and partially demolished two dwellings, the occupants of which had narrow escapes. Other buildings in the vicinity were shaken up by the concussion. James Campbell, the engineer, and Philip Klein, Jr., were badly scalded.

OIL WELL (69). The work on the workhouse oil well owned by T. and G. Gillespie, Pittsburgh, Pa., was resumed on April 25th, but, owing to an accident, nothing further will be done for some time. The boiler used for working the well exploded and was blown 200 feet across the fields. Several men were working about the well at the time, one of whom had just come away from the boiler and gone into the derrick when the accident occurred. No one was hurt.

LOCOMOTIVE (70). The boiler of a locomotive hauling a southbound freight on the Dayton & Michigan railway exploded on April 30th, near Johnson's Station, seven miles north of Dayton, Ohio. The force of the explosion was forward and threw the locomotive across the track. The track and telegraph lines were damaged, and three men were injured, one of them fatally. The cars remained on the track, several of them more or less broken. The injured men are engineer Jacob Ike, fireman Jack Foley, and brakeman O. W. Wood. All were scalded.

ELECTRIC LIGHTING STATION (71). An explosion of one of the horizontal tubular boilers at the Edison Electric Illuminating Company's works at Altoona, Pa., on April 30th, damaged property to the extent of about $1,890. No loss of life or limb.

FURNITURE FACTORY (72). The bottom blow-off pipe attached to the boiler of the Keystone Furniture Company's works, at South Williamsport, Pa., gave out on April 30th scalding the fireman badly. The damage to property was slight.

Boiler Explosions since 1879.

It has been our custom to keep a record of all boiler explosions we could learn of, and publish this record monthly in The Locomotive. Each year, as soon as the returns are all in, we have published a summary of the explosions of the year preceding, giving the number of explosions, the number of persons killed, and the number injured. Having had several calls for the summaries since 1880, we publish them in this issue in a compact form.

Table 1 gives the number of boiler explosions in this country for each month, from 1879 to 1890, inclusive, so far as we have been able to obtain them. Of course it will be understood that a record of this nature is necessarily imperfect, for many explosions that occur are not considered sufficiently "newsy" to interest the public, or they appear in papers that we do not see, though we make every effort to include them all.

According to Table 1, there were 2,159 boiler explosions during the twelve years

Table 1. — Summary of Boiler Explosions by Months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1879	10	16	9	12	5	10	7	14	8	10	13	18	132
1880	19	14	11	11	12	10	14	11	16	11	16	25	170
1881	22	16	15	8	8	15	8	11	14	16	13	13	159
1882	26	15	16	13	14	11	9	18	14	13	7	16	172
1883	22	12	16	10	17	17	10	18	17	15	20	10	184
1884	14	10	15	12	16	16	19	14	12	12	6	6	152
1885	14	20	14	7	12	12	10	9	11	14	15	17	155
1886	19	18	18	7	9	13	26	17	15	10	17	16	185
1887	26	12	8	17	18	14	14	10	14	21	28	16	198
1888	29	22	22	18	16	19	24	20	25	13	15	23	246
1889	18	14	17	14	9	5	17	16	14	28	19	9	180
1890	24	26	22	13	18	20	8	21	15	20	18	21	226
Total Number of Explosions,													2,159

Table 2. — Summary of Deaths by Boiler Explosions.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1879	18	38	4	9	3	34	12	17	12	11	16	34	208
1880	16	22	31	12	30	30	20	9	14	23	18	34	259
1881	38	18	28	6	11	41	16	19	25	15	18	16	251
1882	15	22	27	31	14	18	6	41	18	16	15	48	271
1883	29	18	17	11	30	25	18	18	30	12	37	18	263
1884	17	7	25	18	30	26	37	13	15	31	22	13	254
1885	24	22	20	9	18	14	7	11	11	19	34	31	220
1886	17	6	28	3	18	14	40	30	10	37	26	25	254
1887	27	6	7	14	25	15	15	7	11	71	40	26	264
1888	22	59	23	20	20	20	17	54	37	13	22	24	331
1889	27	45	18	15	7	6	28	27	34	66	21	10	304
1890	24	31	18	11	16	20	12	30	11	28	25	18	244
Total Number of Persons Killed,													3,123

between Jan. 1, 1879, and Jan. 1, 1891. These explosions, it will be seen from Tables 2 and 3, resulted in the death of 3,123 persons, and in more or less serious injury to 4,352 others. We see, therefore, that on an average 1.45 persons are killed per explosion, and 2.02 others are injured. That is, 3.47 persons are disabled, on an average, by every boiler explosion.

In Table 4, the number of explosions each year, and the number of killed and injured, are shown in such a manner as to facilitate comparison.

TABLE 3. — SUMMARY OF PERSONS INJURED BY BOILER EXPLOSIONS.

YEAR.	JAN.	FEB.	MAR.	APR.	MAY.	JUNE.	JULY.	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL.
1879	15	36	20	15	10	20	18	19	11	15	16	18	213
1880	44	23	59	46	59	132	21	21	35	28	33	34	535
1881	35	31	51	11	23	38	19	14	19	32	20	20	313
1882	36	38	31	34	17	25	24	55	28	8	8	44	359
1883	63	23	22	24	28	20	25	17	50	24	65	22	412
1884	19	13	27	15	31	23	35	16	20	17	25	10	251
1885	35	30	28	9	32	6	21	21	13	40	22	21	278
1886	64	25	21	12	19	24	33	24	20	17	27	28	314
1887	31	17	23	43	30	41	20	19	19	65	53	18	388
1888	56	68	37	40	35	38	40	41	56	15	29	50	505
1889	40	33	66	24	18	13	105	36	13	48	19	18	433
1890	44	38	44	19	21	37	12	38	10	32	36	20	351
Total Number of Persons Injured,													4,352

TABLE 4. — SUMMARY OF EXPLOSIONS AND OF KILLED AND INJURED.

YEAR.	EXPLOSIONS.	KILLED.	INJURED.
1879,	132	208	213
1880,	170	259	535
1881,	159	251	313
1882,	172	271	359
1883,	184	263	412
1884,	152	254	251
1885,	155	220	278
1886,	185	254	314
1887,	198	264	388
1888,	246	331	505
1889,	180	304	433
1890,	226	244	351
Totals,	2,159	3,123	4,352

WE read in an exchange of an ingenious arrangement at the Lick Observatory, for automatically discovering comets. A telescope sweeps the heavens systematically throughout the night, and when a comet comes in view its light is received on a piece of selenium, altering its electrical resistance. Upon this the regular polar clock comes into gear and the comet is kept in the field, and an electric bell in Professor Barnard's bedroom notifies him of the discovery. The apparatus distinguishes a comet from a star by means of the difference in the spectra, so that it never gives a false alarm.

A Notable Gas Explosion.

On March 10th a serious explosion took place at the iron-smelting works of Messrs. William Dixon (Limited), Glasgow, Scotland. Five men were killed outright and one was seriously and perhaps fatally injured.

The works where the explosion occurred are in the southern part of the city and are familiar to most visitors to Glasgow on account of the brilliant flare of the furnace fires, the reflection of which at night is visible over an area many miles in extent. Several years ago the managers of the firm directed their attention to the utilization of the waste gases set free in the process of iron-smelting, and somewhat more than eighteen months ago gas-purifying and sulphate of ammonia manufacturing works were set in operation. The products of combustion after leaving the furnaces were conducted along a main pipe six feet in diameter to a dust-box, where they were passed four times through water, and the temperature was reduced from 500° to 120°. After being freed from tar and other heavy products, the gas passed onwards to the condensers, whose pipes were about three miles and a half in length. Thence the gas was conveyed into the scrubbers, where it was finally washed and cleared of impurities before being conducted to the boilers and heaters.

The explosion occurred in the scrubbers, a series of four circular towers, each 18 feet in diameter and 120 feet in height. Externally they were constructed of iron plates, the edges of which were turned up at right angles and screwed together with bolts. At intervals over their surfaces safety-valves were placed to minimize the effects of explosions; but, as it turned out, these outlets were quite useless to vent the great body of gas which was suddenly exploded. Internally the scrubbing towers are fitted with parallel disks of larch wood, arranged like lattice-work in such a way that while they intercept a current of water and cause it to percolate through the interstices, they broke up the gas as it was drawn through the towers by pumps, and caused it to be washed of its impurities. In common with the rest of the iron works throughout the country, those of the Messrs. Dixon were blown out in the beginning of October, and the whole of the operations stopped on account of the strike of the blast-furnace-men. The dispute ended a week ago, and since then the iron furnaces, six in number, were gradually relighted. Three of them were in blast at the time of the explosion, and in the course of the forenoon a considerable quantity of iron was run off into the pig beds.

The manager, the foreman-engineer, and several workmen were engaged in making arrangements to restart the sulphate works. Accounts vary as to the point which the operations had reached. While some of the men in the works state that the gas had been turned on to the scrubbers, others say that this had not actually been done. Whatever may have been the case, it is a fact that about ten minutes past eleven o'clock, while the workmen were engaged about the first scrubber into which gas passed in order to be purified, a violent explosion occurred. There was a dull rumbling sound, followed by a sharp deafening report, and coincidently a column of flame and smoke shot into the air to a height of about 50 feet. Amid the din of falling débris there was heard the crash of glass from the windows of the houses which hedge in the works on two sides. The whole affair was over in a second, and it was some moments before people in the works could realize that a terrible catastrophe had taken place. Fog of some density hung over the scene, and in the imperfect view which was consequently obtained of the gas apparatus, it was not at first apparent that the explosion had occurred in that quarter. A gentleman who was in an adjoining coal yard was startled by seeing a piece of iron-plating weighing several hundred weight whizzing past him. Thinking that the services of an organized body of men might be required he rang the fire alarm.

There was a general rush in the direction of the scrubbers to rescue the men who had been seen working there. Gas was present in dangerous quantities, and an indication of the risk of approaching too closely was afforded by the occurrence of more than one explosion. These, however, were not of much violence, and no further damage was done. The appearance of the scrubbers was very startling. The one in which the explosion occurred was completely wrecked. The iron shell had been torn to atoms, and the scrubbing disks inside were exposed to view, crushed closely together like the folds of an immense concertina. A gaping rent disfigured the side of another of the towers, and the other two bore traces of the effect of the explosion in the battered condition of the iron work about their summits. At the base of the towers lay a tangled mass of broken iron and other material. Not a man was to be seen, and it was only too evident that the workmen who had been engaged along with the manager must be looked for beneath the débris. The gas from the furnaces had not been turned off at this time. In addition to the risk from explosion there was the danger of injury from material falling from the wrecked scrubber, the remains of which hung over in a very threatening way. Notwithstanding the great danger, however, bands of ready workers were willing to run the risk of personal injury in their desire to be of service to their fellow-workmen. The fate of one of the men was soon placed beyond doubt, for the rescue party in a few minutes found the body of Robert McMillan. Shortly afterwards John Russell, a lad eighteen years of age, was found. Although his collar bone was broken and his head badly injured, he was alive. As he was being removed, he was heard to murmur something about "the stair," from which it is inferred that at the time the explosion occurred he must have been on a circular iron stair which led to the summit of the towers. About half-past twelve o'clock the body of Thomas Guthrie, foreman-engineer, was disinterred. His injuries were of a terrible character. The rescuers were beginning to turn over the ironwork to get at the other men, but operations were stopped for a time, about noon, by the occurrence of a slight explosion at the bottom of the wrecked scrubber. At four o'clock the rescuers relieved the body of Charles Doran, an engineer, who had been seen for some time wedged in the ironwork. It is supposed that he also had been on the stair leading to the top of the towers when the explosion occurred, and, the stair being torn to pieces, he was thrown to the bottom. As the day wore on it became apparent that all the men who had been working at the scrubber, except Russell, had been killed. Shortly after seven o'clock the body of Mr. Millen, the manager, was found underneath the ruins of the spiral staircase between the four towers.

One can only conjecture what caused the disaster. Mr. Clacher, who had charge of the ammonia works, is unable in any way to account for it. "We began working," he stated, "at six o'clock in the morning, putting everything in order, in hope of being able to start the plant in the course of the day. We were pretty nearly ready for starting, and had everything in perfect order. Mr. Millen had been engaged at the works all the morning along with Bob Guthrie, the engineer, and a number of other men, making certain that there was no escape of gas before turning on the works. I was standing with him, but I was taken suddenly ill, and had to leave. I had not left two minutes when the explosion occurred, and I never saw them again. They were standing at the bottom, at the east side of the tower, when I left them, and they must have been instantly killed. Robert Guthrie's body was found at the bottom of the tower, near where I had left him. I cannot in any way account for the accident. There must have been gas somewhere, but it could not have come from the furnace, as it had not been turned on for working. I do not see how there could have been any accumulation of gas from former workings. The works have been idle for about five months, and air has been blown through them again and again. Men have been all in through the tubes, cleaning them and putting them in order for recommencing operations."

We are indebted to the *Glasgow Herald* for this account.

Superheated Water.

A correspondent writes concerning "mysterious" boiler explosions as follows: "Permit me to give you my version of the phenomena, which I preface by asserting that the pressure of steam in a boiler is never *greater* than that due to the temperature of the water from which it arises. [Certainly a very reasonable and probable assertion. — Ed.] It is a well-established fact that the pressure of steam does not always indicate the temperature of the water from which it arises, and that the temperature of water may, under favorable conditions, be raised to a point very much higher than that indicated by the pressure. A smooth boiler, under which a slow, even fire is kept, and from which no steam is used, is in a favorable condition for superheating water, if I may use this term. If distilled water is put into a small smooth platinum dish, and exposed to a slow steady heat, the water may be heated to such an extent that it will explode by dropping some cold water into it. In making this experiment drafts of air and jarring of the dish must be avoided, as the molecules of water must not be disturbed. Suppose, now, that a slow fire is kept under a boiler from which no steam is being used. Does it not seem reasonable to assume that the water might be heated above the pressure indication? Every engineer of any experience, who is a good observer, must have noticed that at times, when his engine has been at rest, and the safety-valve is blowing off a little, the sudden starting of his engine will cause more steam to escape from the safety-valve. As the removal of part of the steam cannot increase the pressure, the cause of this must be looked for in the superheating of the water in the boiler. There is no doubt that superheating is a frequent occurrence, but it usually amounts to only a few degrees, and hence causes no disturbances. If, however, favorable circumstances exist, water in a boiler may be heated to a temperature which may cause an explosion, when these conditions are disturbed. There is no doubt in my mind that most of these 'unaccountable' explosions occur when no steam has been used from the boiler for some time, and the conditions for superheating the water have been favorable."

Our correspondent has evidently given this question very careful consideration, but there are one or two points to which we should like to call his attention. In the first place we do not know that experimenters have successfully superheated any very large quantity of water. The experiment is admitted to be a delicate one, requiring certain precautions to insure its success, even with small bodies of water. And, secondly, a smooth containing vessel is required if good results are to be obtained, and we think a steam boiler would hardly be smooth enough. Of course, we cannot deny that the effect may be produced in boilers; but, until there are more definite experimental data at hand, we think, to say the least, that there is room for serious doubt.

It is true that many explosions take place just as the engine is started up, but this is what we might perhaps expect if the boiler was previously strained almost to the point of rupture. The removal of a little steam, although it would reduce the average pressure, might cause a sudden redistribution of strains that the boiler could not stand, even when it had withstood a slightly higher pressure that was brought to bear upon it very gradually.

The Locomotive.

HARTFORD, JUNE 15, 1891.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

WE note a small typographical error on the second page of our last issue. In the place of "to those acquainted with the manufacture of steel," read "to those *un*acquainted," etc. The error crept in in over-running the cut.

IN THE LOCOMOTIVE for May, 1890, we noticed the fourteenth edition of Sinclair's *Locomotive Engine Running and Management*, published by John Wiley & Sons. The eighteenth edition of the same work is now out, and no doubt other editions will follow. The present volume contains twenty-four pages of new matter, describing the construction of the locomotive. It deserves the highest praise.

Inflammable Steam.

A correspondent wrote to us some time ago, as follows: "At any time in extreme cold weather when we crowd our hot-water heating boiler, the air cock in the radiator, when opened, gives steam, and, judging from the smell, hydrogen gas. Under certain conditions we can at any time get the gas alone, and upon ignition it burns with the characteristic blue hydrogen flame. This gas is produced in the boiler when there is no possibility of low water, inasmuch as the expansion and supply tank, together with the piping and radiators, hold several times as much as the boiler, and are at an average height of from fifteen to eighteen feet above the top of the boiler. What I desire to lay before you is the following: (1) That a boiler used for heating by hot water with a stand-pipe head of fifteen feet of water (say eight pounds to the square inch) produces hydrogen gas when fired hard; (2) Any boiler will do the same under certain circumstances — that is, will not only vaporize the water, but decompose a certain portion of it also, the oxygen of the water uniting with the iron, and the hydrogen passing off with the steam; (3) Under these conditions every boiler in service will contain water, steam, hydrogen gas, and possibly air. Supposing some air to be present, we have a very highly explosive mixture, or, more properly speaking, detonating mixture; for the explosive combination of oxygen with hydrogen resembles the action of nitroglycerine rather than of gunpowder. I intended to construct an apparatus showing this generation of hydrogen, and experiment with it. I have not had the time, however, so I submit the question to you."

It is not easy to answer our correspondent's letter in a satisfactory manner without examining the gases that come from the air-cock on his radiator. We believe he is mistaken about the generation of hydrogen in boilers, however; for all our experimental knowledge indicates that it is not possible to dissociate water into its elements at any temperature occurring in boilers, unless the oxygen is absorbed by something. In a boiler the only thing that could absorb it would be the plates and tubes of which the boiler consists; and if, as he supposes, the oxygen is taken up by the iron, a coat of iron-rust would quickly form on the side of the shell. Now, either this coating of rust would protect the shell from further action, in which case hydrogen would cease to be given off, or else it would not protect the shell, and the action would go on, and the boiler would rust out in the course of time, and be ruined. Now, experience shows that boilers do not fail by rusting out, unless there is some corrosive substance in the feed water. It must be admitted that feed-pipes and heaters, in which pure, *warm*, but not boiling water stands, do rust out in the manner outlined above; but boilers do not do so when they are in use. It might be said that sufficient hydrogen would be given off by the rusting of the pipes to cause a dangerous accumulation of hydrogen. In the hot-water heating system that our correspondent describes there is a possibility of such action, if the water he uses is pure and soft; but we should not be willing to admit, without investigating things ourselves, that enough gas to burn would be generated in the pipes. It seems much more likely that kerosene or some petroleum compound is used by the fireman to keep the heating boiler free from scale. Inflammable gases might be distilled off in this way, and might perhaps be lighted at the air-cock under some circumstances. This explanation seems the more probable, especially since our correspondent mentions the noticeable *odor* of the gas. Hydrogen has no odor whatever, while many of the volatile hydrocarbons have. (In preparing hydrogen in a small way a sharp smell is often noticed. This is not due to the gas itself, but probably to the fine mist of acid that the bubbles of gas carry along with them. The same sharp smell is noticeable in preparing other gases.)

The "Savannah."

In a recent number of the *Scientific American Supplement* there is some interesting information concerning the famous steamer *Savannah*. The *Savannah's* first trip was from New York to the city of Savannah. She then proceeded directly to Liverpool, making the passage in eighteen days. She then remained in port for about four weeks, after which she proceeded to St. Petersburg, touching at Stockholm, where she took Lord Lyndoch aboard. Of course her passage excited great enthusiasm, and Lord Lyndoch was so well pleased with his trip that he presented the silver tea-kettle shown herewith to Capt. Moses Rodgers, who was in command. The gift was accompanied by the following letter:

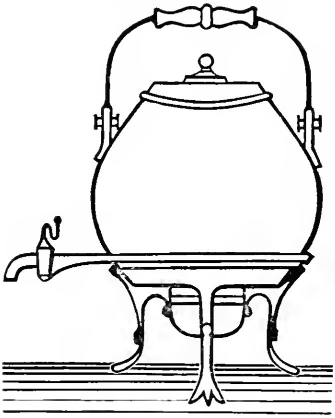
"St. Petersburg, 15th Sept., 1819.

"Dear Sir: I trust you will do me the favor to receive the small tea-kettle (or coffee pot) which I take the liberty of sending, as a slight token of my regard, and which may be useful at Mrs. Rodgers' tea table. I beg, too, that you will believe me most sincere in assuring you of the great satisfaction I had in making the passage from Stockholm on board the *Savannah*.

"It gave me the opportunity of coming here in the most agreeable manner possible, and of admiring the successful efforts of your powerful mind.

"With best wishes for your future welfare, in which Mrs. Graham desires to join, I remain, dear sir, most truly and obediently yours, LYNDOCH.

"Capt. Rodgers, of the *Savannah*."



The inscription on the tea kettle is as follows:

"Presented to Captain Moses Rodgers
of the steamship *Savannah*.
Being the first steam vessel that had
crossed the Atlantic.
By Sir Thomas Graham — Lord Lyndoch,
a passenger from Stockholm to St. Petersburg,
September 15, 1819."

The testimonial is described as having "a beautiful false bottom, supported by three carved legs with ornamental claw feet, with a small vessel in the form of a lamp, on the top of which is a silver guard for the support of the kettle." The whole is lined with gold, and stands ten inches high.

Captain Moses Rodgers' son was engineer of the ill-fated steamer *Arctic*, of the Collins line, which was lost at sea many years ago. His grandson, George W. Rogers, was one of the Hartford Steam Boiler Inspection and Insurance Company's inspectors for the eight years preceding his death.

A Table for Calculating the Areas of Segments.

THE accompanying table was published in THE LOCOMOTIVE five years ago, and it has proved so serviceable that we reproduce it in this issue in a modified form.

The changes consist in the rearrangement of the columns and in the use of a different style of figures. Although the figures in the present table are smaller than before, it is believed that fewer mistakes will be made with them. A common error in using a table is the confusion of 3s with 8s; the computer sees an 8, let us say, but he is more or less likely to call it a 3, on account of the resemblance between the two. In the present table it will be noticed that the 3s project *below* the line, while the 8s project *above* it, the likelihood of this kind of error being therefore materially lessened. Similarly the 7s and 1s have been made as different as possible, and also the 8s and 6s.

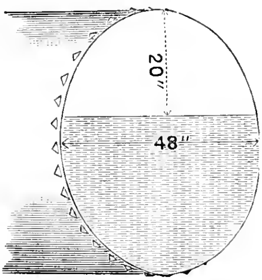
There is another very fruitful source of error in using tables, to which particular attention should be paid. For example, in copying off the area opposite the height .304 it would be very easy to write .201481 instead of .201841. One must be careful not only to copy the correct figures, but to get them in the right order also. Where a figure is doubled, for instance in the area .327883, it is particularly easy to write down some such thing as .327338, or .327388. It is a good plan, after copying a number out of a table, to read carefully the number you have written, and then look back in the table and see if it is right.

These cautionary remarks may appear unnecessary to some, but we have traced so many troublesome mistakes back to simple errors of this kind, that we have come to feel that a little extra care in the first place is well invested. Even the greatest mathematicians make simple mistakes like these we have considered. For instance, in the

Encyclopædia Britannica under *Ether* (p. 570), Maxwell, the famous discoverer of the true nature of light, says that $30.176 \times 16 = 842.8$; whereas any schoolboy can show that $30.176 \times 16 = 482.8$. Evidently he made the calculation correctly and copied the result off wrong.

Now as to the use of the present table. Suppose we wish to find the area of a segment 16 inches high, the diameter of the boiler being, say, 53 inches. First divide the height of the segment by the diameter of the boiler. Thus $16 \div 53 = .302$. Next find this quotient in the column marked HEIGHT in the table, and copy off the AREA opposite to it. The area opposite to .302 is .200003. Next multiply this number by the square of the diameter of the boiler, and the result is the required area of the segment. In this case the square of the diameter $= 53 \times 53 = 2{,}809$, and $2{,}809 \times .200003 = 561.81$ square inches. If we had multiplied .200003 by the square of the diameter of the boiler in *feet*, the result would have been the area of the segment *in square feet*.

The philosophy of this rule is as follows: The table gives the area of circular segments of various heights for a circle whose diameter is unity. The first column marked height is the height of the segment (denoted by the unshaded portion on the upper part of the figure) in parts of the diameter of the boiler. Thus the first number .001 refers to a segment whose height is $\frac{1}{1000}$ of the diameter of the boiler, the second, to one whose height is $\frac{2}{1000}$ of the diameter of the boiler, and similarly for each one-thousandth part of the diameter up to a complete semicircle. $\frac{1}{1000}$ of the diameter of a 6-foot boiler would be $\frac{1}{14}$ of an inch.



As the area of circles, or similar parts of circles of different sizes are directly proportional to the squares of their diameters, it follows that if we wish to find the volume of steam space of any given boiler, for instance one whose diameter is four feet, with water line 20 inches from the top, it will only be necessary to find what part of the diameter, 4 feet, the 20 inches height of steam space is, find the quotient in the column of heights in the table, take out the corresponding area and multiply it by the square of the diameter, which in this case would be $4 \times 4 = 16$. Thus:—$20 \div 48 = .417$. In the table the area of a segment whose height is .417 is seen to be .310082. This multiplied by 16 gives 4.961 square feet for the area of the cross section of the steam space. This area multiplied by the length of the boiler will give the volume of steam space in cubic feet. In the case of a 16-foot boiler this would be $4.961 \times 16 = 79.38$ cubic feet.

The table is extracted from Trautwine's *Engineers' Pocket Book*, and as it gives results for such small increments of height, it will be found of great value where accuracy is desired.

The volume of water space is easily found by subtracting the area of steam space from area of whole boiler, deducting area of tubes, and multiplying by the length of boiler, as in the former case.

The table will also be found useful when designing boilers in calculating the area of portions of the head above the tubes which require bracing, or for any purpose where it is required to know the area of a segment of a circle.

Table of the Areas of Circular Segments for Diameter = 1.

Height.	Area.	Height.	Area.	Height.	Area.	Height.	Area.
.001	.000 042	.064	.021 168	.127	.057 991	.190	.103 900
.002	.000 119	.065	.021 660	.128	.058 658	.191	.104 686
.003	.000 219	.066	.022 155	.129	.059 328	.192	.105 472
.004	.000 337	.067	.022 653	.130	.059 999	.193	.106 261
.005	.000 471	.068	.023 155	.131	.060 673	.194	.107 051
.006	.000 619	.069	.023 660	.132	.061 349	.195	.107 843
.007	.000 779	.070	.024 168	.133	.062 027	.196	.108 636
.008	.000 952	.071	.024 680	.134	.062 707	.197	.109 431
.009	.001 135	.072	.025 196	.135	.063 389	.198	.110 227
.010	.001 329	.073	.025 714	.136	.064 074	.199	.111 025
.011	.001 533	.074	.026 236	.137	.064 761	.200	.111 824
.012	.001 746	.075	.026 761	.138	.065 449	.201	.112 625
.013	.001 969	.076	.027 290	.139	.066 140	.202	.113 427
.014	.002 199	.077	.027 821	.140	.066 833	.203	.114 231
.015	.002 438	.078	.028 356	.141	.067 528	.204	.115 036
.016	.002 685	.079	.028 894	.142	.068 225	.205	.115 842
.017	.002 940	.080	.029 435	.143	.068 924	.206	.116 651
.018	.003 202	.081	.029 979	.144	.069 626	.207	.117 460
.019	.003 472	.082	.030 526	.145	.070 329	.208	.118 271
.020	.003 749	.083	.031 077	.146	.071 034	.209	.119 084
.021	.004 032	.084	.031 630	.147	.071 741	.210	.119 898
.022	.004 322	.085	.032 186	.148	.072 450	.211	.120 713
.023	.004 619	.086	.032 746	.149	.073 162	.212	.121 530
.024	.004 922	.087	.033 308	.150	.073 875	.213	.122 348
.025	.005 231	.088	.033 873	.151	.074 590	.214	.123 167
.026	.005 546	.089	.034 441	.152	.075 307	.215	.123 988
.027	.005 867	.090	.035 012	.153	.076 026	.216	.124 811
.028	.006 194	.091	.035 586	.154	.076 747	.217	.125 634
.029	.006 527	.092	.036 162	.155	.077 470	.218	.126 459
.030	.006 866	.093	.036 742	.156	.078 194	.219	.127 286
.031	.007 209	.094	.037 324	.157	.078 921	.220	.128 114
.032	.007 559	.095	.037 909	.158	.079 650	.221	.128 943
.033	.007 913	.096	.038 497	.159	.080 380	.222	.129 773
.034	.008 273	.097	.039 087	.160	.081 112	.223	.130 605
.035	.008 638	.098	.039 681	.161	.081 847	.224	.131 438
.036	.009 008	.099	.040 277	.162	.082 582	.225	.132 273
.037	.009 383	.100	.040 875	.163	.083 320	.226	.133 109
.038	.009 764	.101	.041 477	.164	.084 060	.227	.133 946
.039	.010 148	.102	.042 081	.165	.084 801	.228	.134 784
.040	.010 538	.103	.042 687	.166	.085 545	.229	.135 624
.041	.010 932	.104	.043 296	.167	.086 290	.230	.136 465
.042	.011 331	.105	.043 908	.168	.087 037	.231	.137 307
.043	.011 734	.106	.044 523	.169	.087 785	.232	.138 151
.044	.012 142	.107	.045 140	.170	.088 536	.233	.138 996
.045	.012 555	.108	.045 759	.171	.089 288	.234	.139 842
.046	.012 971	.109	.046 381	.172	.090 042	.235	.140 689
.047	.013 393	.110	.047 006	.173	.090 797	.236	.141 538
.048	.013 818	.111	.047 633	.174	.091 555	.237	.142 388
.049	.014 248	.112	.048 262	.175	.092 314	.238	.143 239
.050	.014 681	.113	.048 894	.176	.093 074	.239	.144 091
.051	.015 119	.114	.049 529	.177	.093 837	.240	.144 945
.052	.015 561	.115	.050 165	.178	.094 601	.241	.145 800
.053	.016 008	.116	.050 805	.179	.095 367	.242	.146 656
.054	.016 458	.117	.051 446	.180	.096 135	.243	.147 513
.055	.016 912	.118	.052 090	.181	.096 904	.244	.148 371
.056	.017 369	.119	.052 737	.182	.097 675	.245	.149 231
.057	.017 831	.120	.053 385	.183	.098 447	.246	.150 091
.058	.018 297	.121	.054 037	.184	.099 221	.247	.150 953
.059	.018 766	.122	.054 690	.185	.099 997	.248	.151 816
.060	.019 239	.123	.055 346	.186	.100 774	.249	.152 681
.061	.019 716	.124	.056 004	.187	.101 553	.250	.153 546
.062	.020 197	.125	.056 664	.188	.102 334	....	....
.063	.020 681	.126	.057 327	.189	.103 116	....	....

Table of the Areas of Circular Segments for Diameter = 1.

Height.	Area.	Height.	Area.	Height.	Area.	Height.	Area.
.251	.154 413	.314	.211 083	.377	.270 951	.440	.332 843
.252	.155 281	.315	.212 011	.378	.271 921	.441	.333 836
.253	.156 149	.316	.212 941	.379	.272 891	.442	.334 829
.254	.157 019	.317	.213 871	.380	.273 861	.443	.335 823
.255	.157 891	.318	.214 802	.381	.274 832	.444	.336 816
.256	.158 763	.319	.215 734	.382	.275 804	.445	.337 810
.257	.159 636	.320	.216 666	.383	.276 776	.446	.338 804
.258	.160 511	.321	.217 600	.384	.277 748	.447	.339 799
.259	.161 386	.322	.218 534	.385	.278 721	.448	.340 793
.260	.162 263	.323	.219 469	.386	.279 695	.449	.341 788
.261	.163 141	.324	.220 404	.387	.280 669	.450	.342 783
.262	.164 020	.325	.221 341	.388	.281 643	.451	.343 778
.263	.164 900	.326	.222 278	.389	.282 618	.452	.344 773
.264	.165 781	.327	.223 216	.390	.283 593	.453	.345 768
.265	.166 663	.328	.224 154	.391	.284 569	.454	.346 764
.266	.167 546	.329	.225 094	.392	.285 545	.455	.347 760
.267	.168 431	.330	.226 034	.393	.286 521	.456	.348 756
.268	.169 316	.331	.226 974	.394	.287 499	.457	.349 752
.269	.170 202	.332	.227 916	.395	.288 476	.458	.350 749
.270	.171 090	.333	.228 858	.396	.289 454	.459	.351 745
.271	.171 978	.334	.229 801	.397	.290 432	.460	.352 742
.272	.172 868	.335	.230 745	.398	.291 411	.461	.353 739
.273	.173 758	.336	.231 689	.399	.292 390	.462	.354 736
.274	.174 650	.337	.232 634	.400	.293 370	.463	.355 733
.275	.175 542	.338	.233 580	.401	.294 350	.464	.356 730
.276	.176 436	.339	.234 526	.402	.295 330	.465	.357 728
.277	.177 330	.340	.235 473	.403	.296 311	.466	.358 725
.278	.178 226	.341	.236 421	.404	.297 292	.467	.359 723
.279	.179 122	.342	.237 369	.405	.298 274	.468	.360 721
.280	.180 020	.343	.238 319	.406	.299 256	.469	.361 719
.281	.180 918	.344	.239 268	.407	.300 238	.470	.362 717
.282	.181 818	.345	.240 219	.408	.301 221	.471	.363 715
.283	.182 718	.346	.241 170	.409	.302 204	.472	.364 714
.284	.183 619	.347	.242 122	.410	.303 187	.473	.365 712
.285	.184 522	.348	.243 074	.411	.304 171	.474	.366 711
.286	.185 425	.349	.244 027	.412	.305 156	.475	.367 710
.287	.186 329	.350	.244 980	.413	.306 140	.476	.368 708
.288	.187 235	.351	.245 935	.414	.307 125	.477	.369 707
.289	.188 141	.352	.246 890	.415	.308 110	.478	.370 706
.290	.189 048	.353	.247 845	.416	.309 096	.479	.371 705
.291	.189 956	.354	.248 801	.417	.310 082	.480	.372 704
.292	.190 865	.355	.249 758	.418	.311 068	.481	.373 704
.293	.191 774	.356	.250 715	.419	.312 055	.482	.374 703
.294	.192 685	.357	.251 673	.420	.313 042	.483	.375 702
.295	.193 597	.358	.252 632	.421	.314 029	.484	.376 702
.296	.194 509	.359	.253 591	.422	.315 017	.485	.377 701
.297	.195 423	.360	.254 551	.423	.316 005	.486	.378 701
.298	.196 337	.361	.255 511	.424	.316 993	.487	.379 701
.299	.197 252	.362	.256 472	.425	.317 981	.488	.380 700
.300	.198 168	.363	.257 433	.426	.318 970	.489	.381 700
.301	.199 085	.364	.258 395	.427	.319 959	.490	.382 700
.302	.200 003	.365	.259 358	.428	.320 949	.491	.383 700
.303	.200 922	.366	.260 321	.429	.321 938	.492	.384 699
.304	.201 841	.367	.261 285	.430	.322 928	.493	.385 699
.305	.202 762	.368	.262 249	.431	.323 919	.494	.386 699
.306	.203 683	.369	.263 214	.432	.324 909	.495	.387 699
.307	.204 605	.370	.264 179	.433	.325 900	.496	.388 699
.308	.205 528	.371	.265 145	.434	.326 891	.497	.389 699
.309	.206 452	.372	.266 111	.435	.327 883	.498	.390 699
.310	.207 376	.373	.267 078	.436	.328 874	.499	.391 699
.311	.208 302	.374	.268 046	.437	.329 866	.500	.392 699
.312	.209 228	.375	.269 014	.438	.330 858	....	....
.313	.210 155	.376	.269 982	.439	.331 851	....	....

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Riveted Joints — Their Proportions and Strength.*

BY J. M. ALLEN OF HARTFORD, CONN.

The many uses to which iron and steel are applied in this age of great steamships, bridges, and steam boilers, makes it important that the question, how to join the plates and parts together so as to secure the greatest strength, should be carefully and intelligently investigated. The old rule of thumb will not be sufficient in this age of progress. Steamships that travel with almost the average speed of the steam cars are subjected to enormous strains in their contest with the waves and storms. The bridges of iron and steel of long span are also subjected to sudden and heavy strains by passing trains, and steam boilers, in these days of large diameters and high pressures, are compelled to

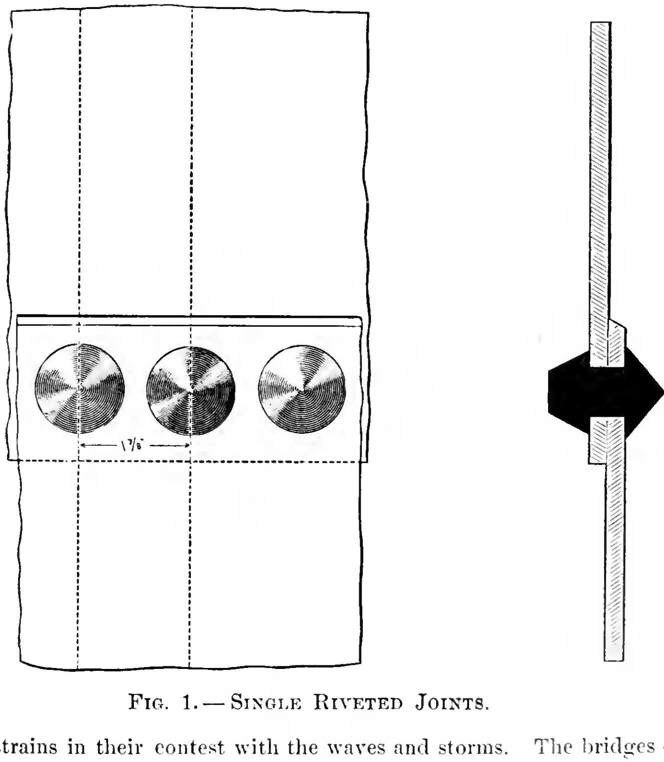

FIG. 1. — SINGLE RIVETED JOINTS.

* A Sibley College lecture, delivered at Cornell University on April 17, 1891, by Mr. J. M. Allen, President of this company.

carry loads that would have been impossible twenty-five years ago. In all these departments of engineering, the riveted joint has a conspicuous and important place. Upon the efficiency of these joints the safety and durability of these structures largely depend. I will not discuss this question with reference to its bearing upon steamships and bridges, but will confine myself to the importance of a proper and intelligent understanding of the various forms of riveted joints as applied in the construction of steam-boilers. Up to the year 1838, there had been little or no scientific investigation of this subject. In the early part of this century, boilers were used only at low pressures. Most of the engines were of the condensing type. But the rapid introduction of steam power in the industrial world, with the improvements in boilers and engines, soon called for higher pressures and stronger boilers. In 1838, Sir William Fairbairn conceived the importance of thoroughly investigating the question of proper construction of boilers, with a view to greater safety and efficiency. He made numerous practical tests of the strength of materials, particularly of iron, and also of the strength of riveted joints, the results of which are in some cases accepted to-day. It is interesting to read his account of these experiments. He was working in a new field, and the results of his careful and painstaking work have laid us all under great obligation. I quote from him the following in regard to riveted joints: "Up to the present time nothing of consequence has been done to improve or enhance the value of this process. We possess no facts or experiments calculated to establish principles sufficient to guide our operations in effecting constructions of this kind, on which the lives of the public as well as the property of individuals depend. In fact, such has been our ignorance of the relative strength of plates and their riveted joints, that, until the commencement of the present inquiry, the subject was considered of scarcely sufficient importance to merit attention. Even now, it is by many assumed that a well-riveted joint is stronger than the plate itself, and a number of persons, judging from appearances alone, concur in that opinion. Now, this is a great mistake; and, although the double thickness of the joint indicates increased strength, it is nevertheless much weaker than the solid plate, a circumstance of some importance, as we hope to show in the following experiments."

Without going through the details of his experiments, I will simply give his conclusions. He says from the foregoing: "We may fairly assume the following relative strengths as the value of plates with their riveted joints:

"Taking the strength of the plate at 100, the strength of the doubled-riveted joint would be 70, and the strength of the single-riveted joint would be 56."

SINGLE-RIVETED JOINTS.

In calculating the strength of a single-riveted joint we must know — *First*, what the tensile strength of the iron or steel plate is, from tensile test; *second*, the diameter and pitch of the rivets; and *third*, the resistance to shearing per square inch of the material of which the rivets are made. On this latter requirement, there has been no little discussion. It was formerly assumed, when only iron plates and iron rivets were used, that the shearing resistance of a square inch of rivet was equal to the tensile strength of a square inch of the rivet itself or of the plate. That is, if we have iron of a tensile strength of 45,000 lb. per square inch, the shearing resistance of a square inch of rivet would be 45,000 lb. On this assumption it would be only necessary to so arrange the diameter and pitch of rivets that the area of rivet or rivets to be sheared should exactly equal the net section of plate to secure a perfect joint. Later experiments, together with improvements in the manufacture of iron, and the introduction of steel, have changed these conditions relatively. While the shearing resistance of rivets per square inch has been, and even to-day is, by many assumed to be 45,000 lbs. per square inch, the assumption has arisen, no doubt, from the fact that the rivets rarely shear. I have examined many exploded boilers, and the fractures have almost invariably been through the solid plate or along the line of rivets. It is very rare that the rivets shear. This, no doubt, arises from the fact that the pitch of the rivets was out of proportion to the net section of plate. The old rule seemed to be, the more rivets, the stronger the joint. There was, no doubt, a desire on the part of the boiler-makers to make a tight joint, and they thought that if they pitched the rivets wider it would be difficult to calk the joint so that it would be steam and water tight. One would quite naturally assume that steel plates should be riveted with steel rivets, but such is not the usual practice. Most of the boilers now constructed in this country are made of steel plates, and they are largely riveted with iron rivets. In this country there have been comparatively few experiments on the strength of riveted joints made of steel plates and steel rivets, and as the general practice is to use iron rivets with both iron and steel plates, I confine myself here to the discussion of the iron rivet. I will say, however, that in England very careful experiments have been made, and a large percentage of strength is given to steel rivets over iron rivets. The details of these experiments can be found in Wilson on *Steam Boilers*, and particularly, and very full in detail, in D. K. Clarke's recent work on *Steam Engines and Steam Boilers*. When the true value of the steel rivet is fully decided, and its use becomes general in the country, that value can be easily substituted for the value of iron rivets in the calculations of the strength of riveted joints, the other elements in the problem remaining the same. What value then, shall we give to the iron rivet when used in connection with steel or iron plates? In settling this question I have not only been aided by the experiments of English engineers, but I have availed myself of the results of experiments made on the large Emery testing machine at the U. S. Arsenal at Watertown, Mass. These experiments have been made with American iron and steel, and hence will be valuable to us all in our practical work in this country. In a series of five experiments with steel plates and iron rivets, holes punched, the shearing resistance per square inch was as follows: 39,740 lb., 38,190 lb., 36,770 lb., 38,638 lb., and 41,100 lb. In view of these results and other similar experiments, I assume 38,000 lb. per square inch as a safe estimate of the single shearing resistance of iron rivets in steel plates. Later experiments may change these figures slightly. In these experiments the steel plate was 55,000 lb. tensile strength per square inch. Assuming then 38,000 lb. as the safe estimate, we must decide upon the thickness of plate, diameter of rivet hole, and pitch of rivets. In deciding upon these elements in the problem we must so adjust the size and pitch of rivets as to make the shearing resistance of the rivets as near the strength of net section of plate as possible. I will assume the elements of the problem to be as follows:

Steel plate, tensile strength per square inch of section, 55,000 lb.
Thickness of plate $\frac{5}{16}$ in. = decimal 0.3125.
Diameter rivet holes, $\frac{13}{16}$ in. = decimal 0.8125.
Area of rivet hole = decimal 0.5185.
Pitch of rivets, $1\frac{7}{8}$ in. = decimal 1.875.
Shearing resistance of iron rivets per square inch = 38,000 lb.
Then $1.875 \times 0.3125 \times 55{,}000 = 32{,}226$ lb. = strength solid plate.
$(1.875 - 0.8125) \times 0.3125 \times 55{,}000 = 18{,}262$ lb. = strength net section of plate.
$0.5185 \times 38{,}000 = 19{,}703$ lb. = strength of one rivet in single shear.
Net section of plate is the weakest; therefore:
$18{,}262 \div 32{,}226 = 56.6$ per cent. efficiency of joint.

DOUBLE RIVETED JOINT.

In double riveted joints we find an accession of strength over the single riveted joint of nearly 20 per cent. This arises from the wider lap and the better distribution of the material. The rivets are pitched wider, and there is more rivet area to be sheared, together with a larger percentage of net section of plate to be broken.

Steel plate, tensile strength per square inch of section, 55,000 lb.

Thickness of plate $\frac{3}{8}$ in. = decimal 0.375.

Diameter rivet holes $\frac{15}{16}$ in. = decimal 0.9375.

Area rivet hole = decimal 0.69.

Pitch of rivets $3\frac{1}{16}$ in. = decimal 3.0625.

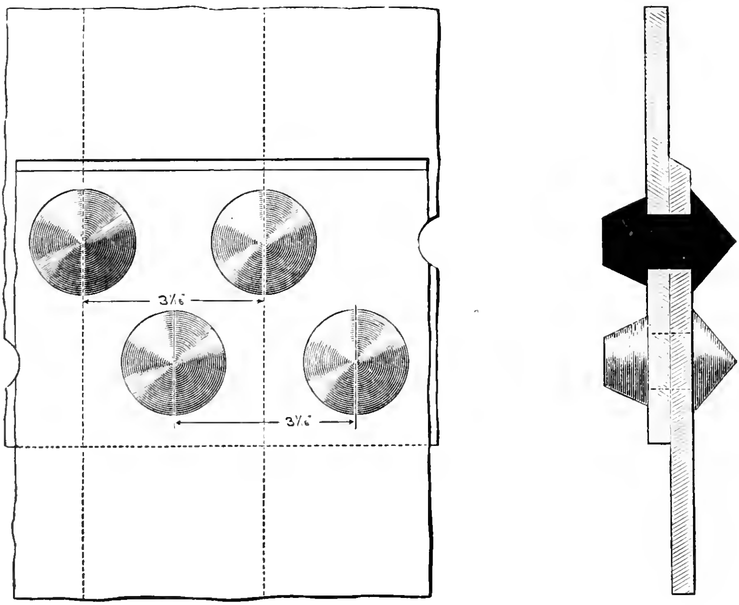

FIG. 2. — DOUBLE RIVETED JOINTS.

Shearing resistance of iron rivets per square inch, 38,000 lb.

Then $3.0625 \times 0.375 \times 55{,}000 = 63{,}164$ lb. = strength of solid plate.

$(3.0625 - 0.9375) \times 0.375 \times 55{,}000 = 43{,}828$ lb. = strength net section of plate.

$0.69 \times 2 \times 38{,}000 = 52{,}440$ lb. = strength of two rivets in single shear.

Net section of plate is the weakest; therefore:

$43{,}828 \div 63{,}164 = 69.3$ per cent. efficiency of joint.

70 per cent. is usually assumed in practice.

TRIPLE RIVETED JOINT.

In a triple lap-riveted joint, we still gain in strength for reasons similar to those above.

Steel plate, tensile strength per square inch of section, 55,000 lb.

Thickness of plate $\frac{3}{8}$ in. = decimal 0.375.

Diameter rivet holes $\frac{13}{16}$ in. = decimal 0.8125.

Area one rivet hole = decimal 0.5185.

Pitch of rivets $3\frac{1}{4}$ in. = decimal 3.25.

Shearing resistance of iron rivets per square in., 38,000 lb.

Then $3.25 \times 0.375 \times 55{,}000 = 57{,}031$ lb. = strength of solid plate.

$(3.25 - 0.8125) \times 0.375 \times 55{,}000 = 50{,}273$ lb. strength net section of plate.

$0.5185 \times 3 \times 38{,}000 = 59{,}109$ lb. strength of three rivets in single shear.

Net section of plate is the weakest; therefore:

$50{,}273 \div 67{,}031 = 75$ per cent. efficiency of joint.

DOUBLE WELT BUTT JOINT.

We now come to the double welt butt joint, triple riveted. I have selected this joint because we use it in practice where boilers of large diameters and high pressures are required. In the double welt joint a new element comes into the problem, viz., that of rivets in double shear. The inner welt is broader than the outer welt, and extends

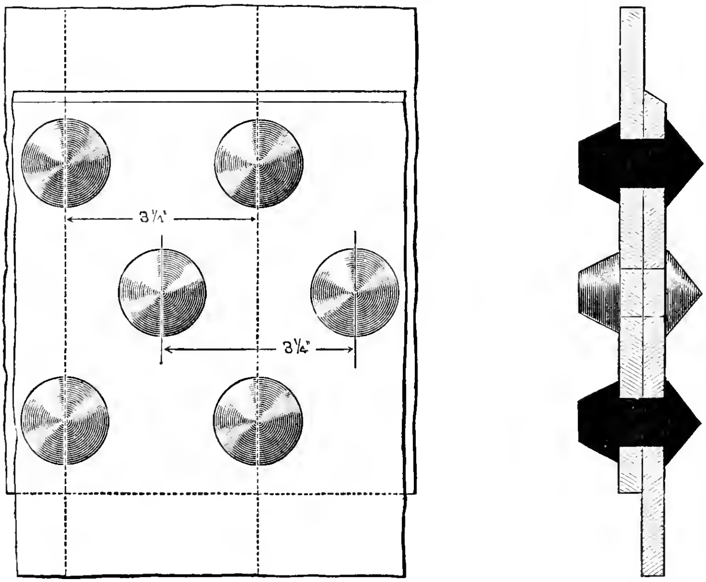

FIG. 3.—TRIPLE RIVETED JOINTS.

far enough beyond the former to enable us to introduce a third row of rivets, which are in single shear, but also are in double pitch. This increases the net section of plate and also adds another rivet to be sheared. All the other rivets are in double shear. The question now arises, What is the value of a rivet in double shear? We have assumed heretofore, that the value of a rivet in single shear was 38,000 lb. per square inch. Now can we assume that the same rivet in double shear has twice the value that it had in single shear? It has been assumed by some writers that such is the case, and up to this time most engineers allow a double value to rivets in double shear. But the conditions are different from those of rivets in single shear. In the former the rivet is sustained by the plates above and below, while in single shear the resistance is confined to one point. An examination of the sheared sections of rivets in single shear usually discloses a slight elongation in the direction of the force applied. The experiments on rivets in single shear, and from which we get our data, have almost always been made on single riveted joints, with narrow strips of iron, as shown in the following Fig. 4.

And it is reasonable to assume that there is a slight tendency in the rivet to lean in the direction of the force applied, which would account for the slight elongation of the sheared section in that direction. An examination of the sheared sections of rivets in double shear shows little or no elongation. The rivets being supported by the plates above and below, the shear is direct and the section is normal in form. Experiments made by the English Admiralty with $\frac{3}{4}$-in. rivets showed that the double shear was about 90 per cent. stronger than the same diameter of rivet in single shear. Chief Engineer Shock, U. S. N., found by experiment that the resistance of bolts of iron to single shear was 40,700 lb. per square inch, and in double shear, 75,300 lb. This gives an increase of strength of 85 per cent. The results of numerous experiments, both in this country and in Europe, show the resistance to double shear to be from 85 to 90 per cent. greater than the same rivets in single shear. From the foregoing I assume 85 per cent. as a fair and safe estimate of the excess of strength of rivets in double shear over those in single shear. We have already assumed that the resistance of rivets per square inch to single shear is 38,000 lb. If we add to this 85 per cent., we shall have 70,300 lb. as the safe estimate of the resistance of iron rivets per square inch to double shear. Further experiments may change these figures slightly. But I regard them as safe for use in all places where joints riveted with iron rivets are used. The use of the double welt butt joint in the construction of boilers is becoming quite common. This arises from the use of boilers of much larger diameter than those formerly used, and also the necessity of higher pressures on account of the introduction of compound engines. With larger diameter and higher pressures, we find ourselves confronted with a very important problem. We must keep within the bounds of safety. For these huge vessels are very destructive to life and property if we disregard the importance of good material, good workmanship, and the well established factors of safety. It is not always safe to assume the highest results obtained by experimental tests. There will always be those who will insist upon higher pressures than safe rules will allow. Hence it becomes important that the consulting engineer shall thoroughly understand the principles of safe construction, and not allow himself to be moved in his judgment when the question of safety is involved. We will now apply the above data to the following problem:

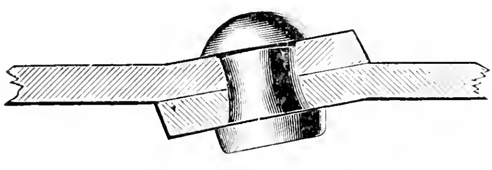

Fig. 4.

Steel plate, tensile strength per square inch of section, 55,000 lb.

Thickness of plate $\frac{3}{8}''$ = decimal 0.375.

Diameter of rivet holes $\frac{13}{16}''$ = decimal 0.8125.

Area of rivet hole = decimal 0.5185.

Pitch of rivets in inner rows $3\frac{1}{4}''$ = decimal 3.25.

Pitch of rivets in outer rows $6\frac{1}{2}''$ = decimal 6.5.

Resistance of rivets in single shear, 38,000 lb.

Resistance of rivets in double shear, 70,300 lb.

$6.5 \times 0.375 \times 55,000 = 134,062$ lb. Strength of solid plate.

$(6.5 - 0.8125) \times 0.375 \times 55,000 = 117,304$ lb. Strength of net section of plate at A B.

$0.5185 \times 4 \times 70,300 = 145,802$ lb. Strength of four rivets in double shear.

$0.5185 \times 38,000 = 19,703$ lb., strength of one rivet in single shear.

This last result must be added to the strength of four rivets in double shear — thus 145,802 + 19,703 = 165,505, shearing strength of all the rivets. The net section of plate is the weakest — therefore, 117,304 ÷ 134,062 = 87.5 per cent. efficiency of joint. It will, no doubt, be observed that the strength of rivets in this joint is largely in excess of the strength of net section of plate, and the question will arise, Why increase the width of the inner covering strip and add two more rivets? As stated above, this was done to increase the net section of plate at A B, and thus increase the efficiency of the

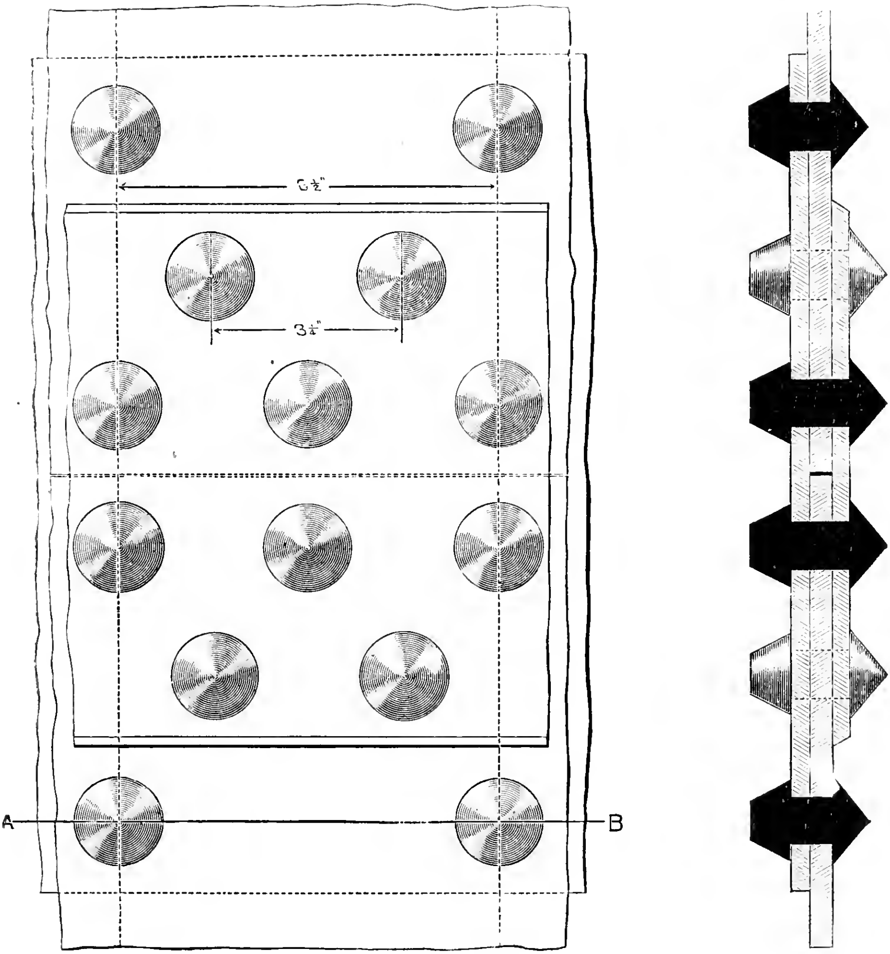

Fig. 5. — Double Welt Butt Joint.

joint. If the inner welt or covering strip had been of the same width as the outer one, the net section of plate would have been greatly reduced and the difference of strength between net section of plate and rivets would have been greater, thus reducing the efficiency of joint. The problem would be as follows:

$6.5 \times 0.375 \times 55{,}000 = 134{,}062$ = strength of solid plate.

$(6.5 - 0.8125 \times 2) \times 0.375 \times 55{,}000 = 100{,}546$. Strength of net section of plate.

$0.5185 \times 4 \times 70{,}300 = 145{,}802$. Strength of four rivets in double shear. Net section of plate is the weakest; therefore, $100{,}546 \div 134{,}062 =$ only 75 per cent. efficiency of joint.

Again, it may be suggested — Why not dispense with one row of rivets in double shear, and extend the inner welt or covering strip so that an outer row of rivets in double pitch and single shear could be used, thus increasing net section of plate as in the original problem, but reducing at the same time the shearing resistance of the rivets? The solution of this problem would be as follows:

$6.5 \times 0.375 \times 55{,}000 = 134{,}062$. Strength of solid plate.

$(6.5 - 0.8125) \times 0.475 \times 55{,}000 = 117{,}304$. Strength of net section of plate.

$0.5185 \times 2 \times 70{,}300 = 72{,}901 =$ strength of two rivets in double shear.

$0.5185 \times 38{,}000 = 19{,}703 =$ strength of one rivet in single shear.

This last result must be added to the result of two rivets in double shear.

$72{,}901 + 11{,}703 = 92{,}604 =$ strength of all the rivets.

The total strength of rivets is the weakest; therefore, $92{,}604 \div 134{,}062 = 69$ per cent. efficiency of joint.

It may be further suggested that a rivet of smaller diameter could be used. I will say that I have also considered such a problem, but have come to the conclusion that the joint, as illustrated and described, for efficiency and freedom from leaks, is the best. I will say here that a joint of this description was carefully made and tested on the Emery machine at the United States Arsenal at Watertown, Mass. The result of the test was within two-tenths of one per cent. of the calculation made, and the line of fracture was through the net section of plate at the outer row of rivets, as we had predicted. It may be interesting to you to know that the company with which I am connected has between forty and fifty thousand boilers under its care, and the risk involved is one hundred and fifty millions of dollars. Hence, we cannot be too careful in our calculations of the strength of boilers. We employ one hundred and twelve men as inspectors, who are constantly at work examining this large number of boilers.

In conclusion I will say, thoroughly understand whatever you undertake to do. The technical school furnishes for you the underlying principles of your profession. The superstructure must be mainly your own work. Grave responsibilities will rest upon you when you become established in your life work. It is a glorious age to live in, and he who by honesty and industry does his part well, will not fail of his reward.

A Mighty Steam Hammer.

The *New York Sun* gives a description of a monster steam hammer, recently erected in the Bethlehem Iron Works at Bethlehem, Pa., for producing armor plates and other heavy forgings. This hammer is the largest in the world, and the *Sun's* account of it may be of interest.

"The hammer building is situated at the extreme eastern end of the works, and covers ground that was formerly an island in the southern channel of the Lehigh River, the river having been turned from its course to make a site for the structure. It is 500 feet long, lighted by windows at the sides and a lantern in the roof, and besides the hammer contains a 6,000-ton hydraulic bending press and an armor-plate rolling mill.

"The hammer and anvil foundations are elaborate specimens of masonry. A pit 58 by 62 feet large was excavated deep down below water-level. Then heavy walls, 30 feet high, were erected on a pile foundation along the northern and southern sides for the hammer frame to rest on.

"In the space between these walls is the foundation for the anvil. It consists of piles driven to bed rock, with a timber frame on top, and on that steel and iron slabs arranged in longitudinal and transverse layers. On this the anvil was built. It consists of twenty-two blocks of solid cast-iron, of an average individual weight of seventy tons, arranged one above the other, in pyramidal shape. The topmost one, on which the material to be forged will rest, is faced with steel.

"The space between the anvil, the frame supporting the hammer, was closed with cribbing, which presents a surface even with the floor line, the only visible portion of the entire mass of oak and iron forming the anvil, which weighs 1,800 tons, being the steel-faced anvil block capping the pyramid. This block is wedge-shaped, being 11 feet long, 6 feet wide at the bottom, and 2 at the top, and 4½ feet high. The hammer and anvil foundations are in no way interlaced; the danger of the anvil foundation giving way is slight, but should it be displaced by the powerful blows, the hammer and its foundation will remain secure.

"Superimposed over this cyclopean mass of masonry and iron work is the hammer—huge, substantial, and powerful, rising to the height of 90 feet.

"In building the frame which supports the hammer there are first two castings weighing 120 tons each which rise somewhat in the form of a quarter-circle on the inside, but almost perpendicular on the outside, to form an arch curving gracefully over the anvil. The two castings are known technically as housings. The longitudinal width of the hammer frame is 42 feet, and the distance from housing to housing is 22 feet on the floor line inside of the arch. The housings, whose bases are 10 feet by 8, are clamped to the foundation walls.

"Above the first arch is a smaller space enclosed by 80-ton castings. These two castings are so constructed as to leave a space ten feet wide in the inside of the frame for the working of the ram or hammer proper. Above these is the steam chest, a large and heavy casting of peculiar shape. The extraordinary number of valve holes, notches, and other indentations which it had to contain, made it the most difficult casting ever turned out here. On top of the steam chest is placed the huge cyclinder, 24 feet high, with an internal diameter of 76 inches.

"Exactly in the center of the arch formed by the housings is the trip or ram, an enormous mass of metal 19½ feet long, 10 feet wide, and 4 feet thick, the weight of which is almost 100 tons. It is composed of three single pieces, the lowest of which, a large block of iron faced with steel, is called the die. It is the die that will strike the metal being forged. The ram works in slides arranged along the inside of the housings, the castings of the section above the housings.

"Connecting the ram with the piston inside of the cyclinder is the piston rod, a splendid specimen of perfectly wrought steel, 40 feet long and 16 inches in diameter. The piston has a stroke of 16½ feet, which is the height that the die can be raised above the anvil. The weight of die, ram, piston rod, and piston together amounts to 125 tons. The cyclinder is single acting, the steam only lifts the hammer, and then allows it to fall of its own weight. It is when this mass of 125 tons is dropped from the height of 16½ feet that the hammer exerts its greatest power.

"The weight of the entire mass of iron and steel used in the construction of the hammer and its frame amounts to more than 800 tons.

"Among the hammer's accompaniments for handling ingots and armor plates are the two most efficient and pneumatic cranes ever constructed. They are capable of carrying 300 tons weight each and have a running motion on their trusses, a transverse motion of trolley, a hoisting, a turning, and a rolling motion, besides three or four others. They are apparently able to do almost anything but turn a somersault.

"The hammer will be used principally for forging armor plates out of ingots, which are made of steel in the casting department, and weigh from 20 to over 100 tons each.

"When in operation the hot ingots will be laid on the anvil and held there by the cranes and shifted and turned by porterbars.

"The piston will be forced up against the top of the cyclinder by the action of the steam introduced into the steam chest by an eight-inch pipe from the boiler house. The steam will then be shut off and exhausted from the cyclinder, and the ponderous ram will drop with full force on the ingot. On account of the extraordinary power of the hammer few reheatings will be necessary.

"The giant was designed by Mr. John Fritz, superintendent of the works, somewhat after the hammer of Schneider & Co. of La Creusot, France, which, next to this one, is the largest in the world."

The Locomotive.

HARTFORD, JULY 15, 1891.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

THE LOCOMOTIVE *can be obtained free by calling at any of the company's agencies.*

Subscription price 50 *cents per year when mailed from this office.*

Bound volumes one dollar each. (Any volume can be supplied.)

Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning. so that we may give proper credit on our books.

WE HAVE received from Mr. George H. Barrus, S.B., a copy of his new book on *Boiler Tests*, which gives the results of one hundred and thirty-seven tests, conducted by the author, on seventy-one boilers. Mr. Barrus's reputation as an expert in these matters led us to expect his book to be interesting and valuable, and our expectations are more than fulfilled. It is a valuable work, and it ought to be on the table of every engineer who is interested in boiler trials. The first part of it consists of explanations of the methods used, and discussions of results, and of different kinds of boilers and fuels, and remarks on the general conditions for securing economy. The second part of the book gives the details of the tests. Horizontal tubular, horizontal double-decked, plain cylinder, vertical tubular, cast-iron sectional, and water tube boilers are included, and a very good idea of what these various kinds of boilers will do under given conditions may be had from the results. In an appendix Mr. Barrus describes his coal calorimeter, and universal steam calorimeter.

The book is issued by Messrs. Gowing & Co., 70 Kilby Street, Boston, and the price is $5.00.

ON page 86 of the June issue of the LOCOMOTIVE the number of persons injured by boiler explosions in July, 1880, is said to be 21. This number was taken from THE LOCOMOTIVE for January, 1881, p. 7; but we find that some copies of the paper for that date give 41 as the number injured in July, 1880, and by looking up the original record it appears that 41 is correct. (THE LOCOMOTIVE for January, 1881, became out of print, and was reissued, so that the proof-reader was undoubtedly responsible for the disagreement observed between different copies of this date.) The correction increases the total number of people injured by boiler explosions in 1880 by 20, so that it should read 555, and the total number of the injured from 1879 to 1890, inclusive, should be 4,372.

Steam Boilers and Geysers.

An esteemed correspondent sends us a copy of a German periodical, *Die Natur*, which contains an article bearing on the question of superheated water. A free translation of the relevant portion of the article follows: "It should be remarked that water may be heated above 212° Fah. without passing into steam, and while it is under ordinary atmospheric pressure, provided it is kept perfectly quiescent; but let the slightest motion be communicated to it, — even the tremor produced by a footstep, — and behold!

the water which was calm and quiet suddenly flashes into steam. This is the mysterious cause of so many steam-boiler explosions, which take place when the valves have been closed for some time, and the boiler quiescent. Indeed, Nature makes the fearful experiment for us in geysers. The renowned chemist, Bunsen, has explained the periodical eruption of geysers in such a satisfactory manner that doubt is no longer possible. A cavern filled with water lies deep in the earth, under the geyser, and the water in this cavern is heated by the earth's internal heat far above 212°, since there is a heavy hydrostatic pressure upon it arising from the weight of water in the passage or natural stand-pipe that leads from the subterranean chamber to the surface of the earth. After a certain time the temperature of the water below rises, so that steam is given off in spite of the pressure, and the column in the exit tube is gradually forced upward. The release of pressure and the disturbance of the water then cause the contents of the subterranean chamber to flash into steam and expel the contents of the exit pipe violently. These eruptions may also be provoked by throwing stones or clods of turf into the basin of the geyser. The water in the cavern below is disturbed by this means, and we have the identical phenomenon that may take place in steam boilers, as already pointed out."

The parallelism here suggested between boilers and geysers is ingenious and interesting, but we still doubt if such action is possible in steam boilers. The experiment of heating water above its boiling point is not an easy one to perform in the laboratory. In the geyser all the conditions are admirably fulfilled, for the subterranean reservoir is deep in the solid earth, protected from every possible natural disturbance except earthquakes, and its temperature is raised slowly and uniformly by heat conducted through walls of rock. What could be more favorable to superheating than these conditions?

But in a steam boiler the water cannot be quiescent, for there must be a constant circulation produced by the fire at one end, and radiation from the other; and a slight tremor, arising from some cause, may usually be felt by standing on a boiler that is under pressure, even when its valves are closed. In performing the experiment in a laboratory it appears to be essential that the containing vessel should be smooth. In the geyser, where everything is almost absolutely still, and the heating is done with perfect uniformity, smoothness is probably not essential; but we should think that under the conditions which actually prevail in boilers the presence of scale, or roughness of any sort, would prevent superheating very effectually.

In spite of our rather strong opinions on the subject we do not wish to say positively that the geyser action does *not* take place in steam boilers; but we think its occurrence is not probable.

Newspapers take delight in annually telling of the usefulness of the ballet in teaching chemistry. Here is the same old item, rejuvenated and elaborated: "The latest feature of the introduction of the instructive and highly moral into the music hall abroad is the *ballet d' action*, in which the dancers 'represent atoms of different elements, which, as the dance develops, unite in groups to form certain well-known chemical combinations.' Among other things thus choregraphically depicted upon the stage is said to be 'the composition of benzole and the formation of aniline and its derivatives.' Mention is also made of a 'masterly Terpsichorean analysis of the hydro-carbons by the premiere danseuse and her assistants, which fairly brought down the house.' This took place at Cologne, but the idea is expected to spread."

Description of a Model of an Improved Marine Engine.

It is only a few years since the compound condensing engine was considered the best possible engine for marine use: but already the triple expansion engine has replaced it in the better class of sea-going vessels, and many comparatively new and costly compound engines are being taken out and replaced by the more economical triple expansion ones. It seems, furthermore, to be only a question of time when these in turn will give way to the quadruple expansion engine, in which steam is four times expanded and then passed into the condenser.

Mr. Frank Chaese, in the employment of the Hartford Steam Boiler Inspection and Insurance Company, has just completed a working model of an engine of this kind, which weighs about thirty pounds and contains upwards of three thousand six hundred parts. The high-pressure cylinder is $\frac{7}{8}$ inch in diameter, the first intermediate cylinder is $1\frac{3}{8}$ inches in diameter, the second intermediate 2 inches, and the low-pressure cylinder $2\frac{13}{16}$ inches. The stroke is $1\frac{3}{4}$ inches, and the engine is designed to make 130 revolutions a minute and run under a boiler pressure of 200 pounds to the square inch. All the cylinders are provided, top and bottom, with relief valves of ample area, with pipes for attaching indicators, and with cylinder drain cocks.

The engine has two cranks set at right angles, the forward one connecting with the piston rod from the high-pressure and first intermediate cylinders, while the aft crank connects with the piston rod of the second intermediate and low-pressure cylinders. All of these cylinders are jacketed with live steam, which enters the jacket at boiler pressure and is dripped into the condenser. In starting up the engine the jacket valve is first opened and steam blown through into the condenser. This heats the cylinders up to the working temperature, and facilitates getting the condenser into operation. Outside of the steam jackets there is an air space, and then comes a non-conducting jacket of asbestos, while outside of all there is a neat wooden lagging composed of alternate strips of mahogany and white maple. The cylinders being arranged in pairs, tandemwise, and the engine being vertical, tail rods were not considered essential, especially as the stuffing boxes have very long sleeves, as will appear later on. The pistons fit the cylinders nearly steam tight, but two grooves are cut in each and packing rings with a diagonal slit are sprung into them.

The usual way to secure the pistons of marine engines to the rods is to make the rods slightly conical where the pistons come, and fasten the pistons securely down on the tapering part by means of jam nuts. The objections to this method are that the piston cannot be adjusted after setting up the engine, and in case of accident or other emergency, they cannot readily be removed. In Mr. Chaese's engine an attempt has been made to overcome these objections by fitting the piston to a collar, which is adjustable to some extent on the rod, and from which the piston may be readily removed.

The stuffing boxes on the crank ends of the lower cylinders do not differ materially from those now in use: but a special arrangement, having distinct advantages over the ordinary stuffing boxes, has been provided between the upper and lower cylinders. A long sleeve that fits over the piston rod is bolted to the lower head of the upper cylinder. On the upper head of the lower cylinder a split stuffing box is bolted, which may be entirely removed from the rod if desired. The bottom of this stuffing box consists of a split collar, which fits around the piston rod, and may also be readily removed. The long sleeve that projects downward from the upper cylinder passes through the gland of the lower stuffing box, and packing is inserted in the box in such a manner that it presses downward against the split collar referred to above, inward against the piston rod and the long sleeve, upward against the gland and the lower end of the sleeve, and outward against the split stuffing box. All the cylinders and valve chambers are fitted up in this way, and the arrangement is effective and simple, since it dispenses with one entire set of stuffing boxes. By removing the split stuffing box and the split collar about the rod, the upper head of the lower cylinder, for instance, may be raised until it rests against the lower head of the upper cylinder; and the pistons and valves may be readily reached for examination, adjustment, or repairs.

The upper cylinders and valves are kept at the proper distance from the lower ones by six columns, which are secured by means of set screws let into their ends. By removing two screws, any one of these columns may be taken out to allow of the removal of pistons, or for giving greater facility of access when packing.

The engine has no receivers, the valves and nozzle being of sufficient size to serve this purpose. The valves are of the piston form, the upper piston being slightly larger than the lower one, so that when the engine is in operation the pressure of steam on this excess of area balances the weight of the valve, spindle, and rods attached. The cranks are set at 90°, and the eccentrics (of which there are four) are at 120° with the cranks. Three of the eccentrics are keyed on, as usual; but the fourth eccentric, which is used on the forward or high-pressure engine in going ahead, is attached to a projection from the shaft by means of a long screw with two nuts, and the lead of this eccentric may be changed by varying the position of these nuts on the thread.

The reversing gear of the engine is operated by steam. It consists of a pair of cylinders arranged as in a pump, the upper one of which is supplied with steam by means of a two-way valve, so that live steam can be admitted to either side of the piston. The lower cylinder is filled with oil, and a passage runs from the upper side of its piston to the under side of it. In this side passage is a valve which locks the reversing gear when it is closed. The piston rod of this oil pump is attached to the lever that controls the links, and the mode of operating the gear is as follows: The valve in the oil passage is closed and steam is turned on in the upper cylinder. The oil valve is now opened quickly or slowly, according as it is desired to reverse the engine quickly or slowly. In event of accident to the steam reversing gear, a small force-pump, to be worked by hand, is provided, which draws oil from one end of the oil cylinder and forces it into the other end, thus shifting the link slowly in the same manner that the steam mechanism does. The passages for oil and steam are cast in the body of the reversing gear, so as to do away with piping. By the method of suspension of the link and block a sort of parallel motion is attained, which greatly lessens the slipping of the block, and gives a quicker admission and cut-off.

The piston rods are screwed into the cross heads, and are provided with jam nuts, so that they can be removed if necessary. The shoes are broad and long, and are provided at their lower ends with brushes that dip into oil boxes and keep the slides oiled. Ample means of lubrication are provided at all points. The bearing against which the wear comes in going ahead, has a detachable plate, so that it can be removed in case of wear. One leg of the frame supporting the engine is utilized as an oil reservoir, and to the front of this leg a revolution-counter is secured.

The condenser has 260 square inches of surface, and is very efficient. Water circulates through the tubes and all around the condensing space. Feed water is taken from the hot well by two pumps operated by side levers from the engine, either one of which has sufficient capacity to supply the boilers. Each pump has an air chamber and a relief valve, so that if the boiler valves are closed the feed pipes will not be ruptured. The pump cylinders are considerably below the level of the water in the hot well, so that they will take boiling water if necessary. To provide for the loss of water that unavoidably occurs, there is a passage between the steam and water spaces of the condenser, in which a valve is placed. All the pumps have pet cocks, so that the engineer may assure himself that they are working properly. The circulating pump is double-acting, and is made larger than usual in order that an ample supply of condensing water may be had, even when the ship is in tropical latitudes. Pipes are dispensed with about the engine wherever this is possible. The bilge pumps are by the side of the circulating pumps, and are operated by the same side levers. The hot well is provided with an escape pipe for vapor, a manhole for cleaning, and a glass gauge for showing the height of water. On the bottom of the condenser is a snifting valve, which prevents the water from backing up in the condenser and choking the engine. The condenser is made in a single casting, as is the bed of the engine itself, and it is provided with mudholes and large, easily accessible end doors for getting at the water side, and with a manhole for getting at the steam side.

The crank shaft is in two sections, exactly alike. Where these sections come together they are flanged, and are secured together by a dowel, which can be removed readily in case it is desired to separate the forward and aft engines. The bearings have brass bushings and oil boxes and a water service leads from the circulating side of the condenser, for use in cooling the bearings should they become heated in spite of the abundant provisions for lubrication. All bearing surfaces are made unusually large.

Just back of the aft main bearing a large gear wheel is secured to the shaft, which engages with a worm driven from an auxiliary engine, entirely distinct from the main engine, which can be readily thrown in and out of gear. This device is very serviceable when it is desired to turn the main shaft slightly, so as to gain access more freely to the parts in cleaning up and repairing. This auxiliary engine is double-acting and has two steam cylinders working on cranks set at right angles. It has no eccentrics, links, or connecting rods, and its valves are operated in a very simple manner by cams on the shaft. It is reversed by reversing the steam by means of a two-way valve. In addition to the two steam cylinders, it has a pair of water cylinders, so that by throwing the worm out of gear it may be used as a powerful feed pump, bilge pump, circulating pump, donkey pump, etc., as necessity may require.

We have now to consider its disconnective features. In case the forward engine breaks down from any cause, steam is first shut off entirely. The forward and aft engines are next separated by removing the dowel that unites the two lengths of shaft on which they operate. The valve between the two intermediate cylinders and the throttle valve into the high pressure cylinder are then closed, and the auxiliary engine for turning the shaft in dock is pressed into service as a circulating pump. Steam is then turned on to the second intermediate and low-pressure cylinders through a reducing valve, and the aft engine is run as a compound condensing engine. It should be said that this reducing valve is serviceable in starting up the large engine at all times, until a proper flow of steam is established through the cylinders. A blow-through pipe to the low-pressure cylinder is also provided, so that the engineer can admit a little live steam into this cylinder if he considers it desirable to do so, at any time.

In case it is the aft engine that breaks down, steam is first shut off as before, and the connecting rod from the low-pressure cylinder is removed from the crank-pin and secured in an out-of-the-way position. The valve between the two intermediate cylinders is closed, and connection is made between the first intermediate steam chest and the condenser. The auxiliary engine is then used as an air pump. Upon opening the throttle valve once more, the forward engine runs as a compound condensing engine.

The thrust-block, instead of being made in the usual form, with collars running in grooves, is provided with conical rollers which run in oil, and have very little friction.

The engine we have described is made to represent an ideal engine of the following dimensions, on a scale of $\frac{3}{4}$ inch to the foot: Diameter of cylinders, high-pressure, 14″; first intermediate, 22″; second intermediate, 32″; low-pressure, 45″; stroke, 28″. Boiler pressure, 200 pounds; speed, 130 revolutions a minute; condenser surface, 700 square feet. When the engine is in full gear, steam is cut off at half stroke in the forward engine, and at five-eighths in the aft engine.

The engine takes up very little room fore and aft. All parts — connecting rods, valve stems, eccentrics, etc., — are in duplicate, and all are readily accessible for repairs.

Mr. Chaese's engine is on exhibition at the home office of this company, and any of our friends who would like to see it are invited to come and do so.

A Fatal Boiler Explosion.

On June 19th there was a disastrous boiler explosion at the Benwood blast furnace, at Martin's Ferry, near Wheeling, W. Va. The clock in the boiler-house stopped at 1.22 A. M., indicating that that was the time of the explosion. There were two batteries of three boilers each, running east and west. They were enclosed by a frame building on the north side of the engine-house, and were heated by natural gas. It was the upper boiler of the lower battery that burst. The boiler passed eastward with terrible speed, landing over a hundred yards away, in the river. The report was deafening, and the explosion made the earth tremble, and shook every building in the upper end of Martin's Ferry, awakening and frightening hundreds of people, most of whom thought a cyclone, or something of the sort, had struck the town. The boiler-house was demolished, and the major part of the north wall of the engine house was blown in. Considerable other damage was also done. Pieces of the boiler, brick, timbers, piping, and débris generally were blown in every direction. The battery was completely demolished, and the other two boilers in the battery were blown out of their settings. The huge smoke stack was blown down and hurled against the hoisting house.

The part of the exploded boiler that landed in the river passed over the ground only a foot above it until reaching the river bank, where it tore up the cinders, and, altering its course slightly, passed through one end of a boat-house moored at the water's edge. The boat-house had three rooms and a kitchen. George W. Roush and his son, Charles, occupied a bed in the east side of the upper room, and Philip Roush and Robert Glenn slept in a bed in the adjoining room. George and Charles Roush lay directly under where the boiler shot through. The father had his right wrist and arm cut, and received a few scratches. Charles Roush had his right arm cut off close to the shoulder, and his face was badly lacerated. He also sustained other injuries about the body, and after suffering for several hours he died. Robert Glenn was hurt about the stomach, and probably received severe internal injuries also.

The fire in the furnace of the exploded boiler was lighted only the day before, and if the explosion had not occurred, the first cast would have been taken on the 19th, at nine o'clock A. M. The cupola was full of melted metal. The furnace had been idle for five months, and it will probably take two months more to get it into running order again.

Charles Bird, the engineer, says the gauge showed 95 pounds of steam two or three minutes before the explosion, and that there were three gauges of water in the boiler.

Strange to say, not a single furnace employe was hurt.

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES—VOL. XII. HARTFORD, CONN., AUGUST, 1891. No. 8.

Pitted Plates.

Grooving is often found, in boilers, around the stay bolts of water legs or furnaces, radiating from the bolts as centers. The plates probably bend backward and forward slightly under the varying pressures; and though the flexure and consequent alteration of the surface may be too small to be seen, it may be great enough to start incipient cracks, and open up the iron to the action of the water.

An instance of pitting, which seems to be due to this cause, is illustrated herewith. The pieces which the cuts represent were cut from a horizontal tubular boiler 48 inches in diameter, which had been in use about six years in a nail works. The plates were of steel, one-quarter of an inch thick, and the boiler was set over a blast furnace, the waste gases from which are used in the place of fuel. The lap from which these pieces were cut came directly over the vertical flue through which the furnace gases were admitted to the boiler.

Naturally there were great and sudden variations in the temperature to which the

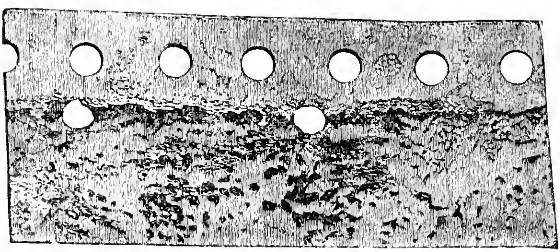

FIG. 1.—A PITTED PLATE (OUTER LAP).

lap was exposed, and the expansion and contraction of the plates at the lap must have been sudden and violent. The plates, being light, would readily transmit heat through to the water; while the lap, being thicker, would not part with its heat so readily, and there would frequently be a considerable difference in temperature between the lap and the plates, which would cause the adjacent parts of the plates to twist and buckle slightly. Water would enter the small fissures so produced, and attack the metal, a fresh surface of which would be continually exposed; and the higher and more varied the temperature became, the more active would be the buckling and corrosion.

A good idea of the violent changes to which the boiler was exposed may be had from the fact that at one moment steam would be blowing off freely at ninety pounds, and a few minutes afterwards the gauge would show only forty pounds.

Such changes in pressure would naturally be accompanied by slight changes in the form of the boiler. The lap being much stiffer than the plates, the greatest motion would take place along the edge of the lap, where the two come together; and we should expect to find the pitting and grooving most severe at this point. This is the fact in almost every such case. It is indicated in Fig. 1, and in Fig. 2 it is evident that the rivet-heads exercised a similar stiffening power over the inside lap: for the outlines of the rivet-heads may be easily traced by the pitting that took place along their edges, where the motion of the metal composing the inner lap was greatest.

The water in the present case was very pure, so that there was no deposit. Had it been less pure, and contained some light scale matter, it is possible that this pitting action would not have occurred, as the scale might have sealed the fissures and protected the plates.

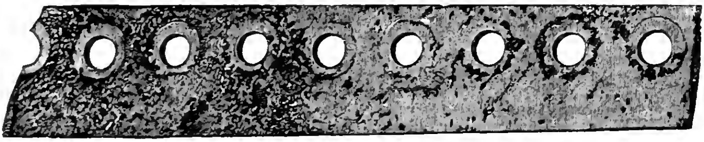

FIG. 2.—A PITTED PLATE (INNER LAP).

When boilers are set as this one was, over a flue leading from a blast furnace, we recommend that the upper end of the flue be curved toward the rear end of the boiler, so that the gases will not impinge directly on the plates, but be delivered horizontally along the under surface of the boiler. Some very troublesome cases of this kind have been cured by this simple expedient.

Inspectors' Reports.

APRIL, 1891.

During this month our inspectors made 5,509 inspection trips, visited 10,706 boilers, inspected 4,341 both internally and externally, and subjected 641 to hydrostatic pressure. The whole number of defects reported reached 9,933, of which 951 were considered dangerous: 40 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	692	25
Cases of incrustation and scale,	1,277	44
Cases of internal grooving,	80	19
Cases of internal corrosion,	378	33
Cases of external corrosion,	576	55
Broken and loose braces and stays,	107	59
Settings defective,	271	36
Furnaces out of shape,	301	11
Fractured plates,	219	69
Burned plates,	183	20
Blistered plates,	326	4
Cases of defective riveting,	2,261	78
Defective heads,	83	32
Serious leakage around tube ends,	1,882	255
Serious leakage at seams,	336	28
Defective water-gauges,	254	46

Nature of Defects.	Whole Number.	Dangerous.
Defective blow-offs,	85	13
Cases of deficiency of water,	14	8
Safety-valves overloaded,	43	20
Safety-valves defective in construction,	46	22
Pressure gauges defective,	343	38
Boilers without pressure gauges,	31	31
Unclassified defects,	145	5
Total,	9,933	951

MAY, 1891.

During this month our inspectors made 5,265 inspection trips, visited 10,418 boilers, inspected 4,939 both internally and externally, and subjected 721 to hydrostatic pressure. The whole number of defects reported reached 11,142, of which 984 were considered dangerous; 63 boilers were considered unsafe for further use. Our usual summary is appended:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	923	47
Cases of incrustation and scale,	1,537	63
Cases of internal grooving,	77	5
Cases of internal corrosion,	408	14
Cases of external corrosion,	675	42
Broken and loose braces and stays,	173	33
Settings defective,	303	35
Furnaces out of shape,	368	10
Fractured plates,	244	60
Burned plates,	219	30
Blistered plates,	312	12
Cases of defective riveting,	2,234	73
Defective heads,	75	14
Serious leakage around tube ends,	2,141	376
Serious leakage at seams,	381	49
Defective water-gauges,	238	23
Defective blow-offs,	117	19
Cases of deficiency of water,	25	9
Safety-valves overloaded,	58	18
Safety-valves defective in construction,	59	21
Pressure-gauges defective,	445	22
Boilers without pressure-gauges,	3	3
Unclassified defects,	127	6
Total,	11,142	984

Boiler Explosions.

MAY, 1891.

MINE (73). On April 12th, a boiler exploded in the shaft house of the American mine, Black Hawk, Colo. Three men, Frank Deng, John Solak, and Fred Otmeyer, lessees of the property, were at work hoisting. Deng and Solak stayed on top, and Otmeyer went down to fill the bucket. They had just fairly begun work, when the explosion occurred. The shock was felt all over the city. The shaft house was scattered in all directions, and parts of the boiler were found several hundred feet away. Deng and Solak were badly hurt, and Solak will die, though Deng may recover.

GOLD MINE (74). The boiler at the Poverty Bar gold mine, Amador Co., Cal., exploded on April 27th, and the proprietor, Joseph Hobert, who had just been altering the governor and was about to examine a leap of steam, was thrown forty or fifty feet in the air and landed in the river, comparatively unhurt. The explosion is not understood, as the boiler was almost new, and only half the allowable head of steam was being carried. (This explosion and the preceding one were received too late to be included among the April explosions in our last issue.)

OIL WELL (75). An oil-well boiler jumped in the creek fifty feet from where it was setting, about 12 or 1 o'clock, on the night of May 1st, in State Fork, W. Va., just as the hands were changing tower. The steam got very high, and the tool dresser went to take off some gas. He had just got back to the derrick when the boiler burst and went up in the air. The hands think it went very high, for it was some time before they heard it strike the ground. Some pieces were found a great distance away.

SAW-MILL (76). The boiler of Mr. Williams's saw-mill on Brasstown Creek, near Hiawassee, Ga., burst with terrific effect on May 2d. Pink Hutchins, the fireman, is fearfully scalded and bruised. He can hardly live. Bud Brown, the off-bearer, was hit by a passing piece of timber and dangerously wounded, and will probably not recover. George Gibson, the sawyer, was blown some distance, but not seriously injured. The saw-mill is a total wreck. The boiler was thrown from 200 to 300 feet from its setting.

ROLLING MILL (77). A battery of three boilers at the Keystone Mill, Second avenue, Pittsburgh, Pa., exploded on May 4th, at 2 o'clock, A. M. Two men were fatally injured, John Briggs and Joseph York. They are badly scalded, and it is not thought there is any chance for recovery for either of them. York was a fireman, and Briggs was a water tender. The battery that blew up was the center one of the four used at the mills. On the side nearest the mills was the new battery that had not yet been placed in operation. No one was near when the explosion occurred, so that an explanation of the cause could not be had. Briggs, York, and a colored man named Cook were the only ones around where the explosion occurred. Patrick Prendergast, another fireman, who tended that battery, had left his post but a moment before to go to the pump for a drink. The boilers were large ones, and made a terrific explosion. The masonry around them was blown away, and the other batteries were damaged. Parts of the tubes and brickwork were blown clear over the mill. The wreck was most complete. The remarkable feature was that greater damage and greater loss of life were not sustained. The explosion threw about 300 men out of employment.

ELECTRIC LIGHT STATION (78). A five-inch tube burst in one of the boilers of the Electric Light Company's station in Akron, Ohio, on May 4th, sending a cloud of burning coal and white hot fire-brick out of the furnace door. The damage was not great, and no one was killed.

SAW-MILL (?) (79). A boiler exploded three miles east of Lawrenceville, Ga., on May 6th, in the Lewis Brother's mill, on the Georgia, Carolina & Northern railroad. J. H. Henley, white, and Charles Proctor, colored, were instantly killed, and Will Hurrington, colored, had his eyes put out, and was badly bruised about the body.

CREAMERY (80). A new boiler, which had been placed in position in J. N. Hadley's creamery, Mooresville, Ind., exploded on May 7th, while it was "being tested."

Considerable damage was done, and George Nelson, engineer, narrowly escaped death. We presume the "test" consisted in firing the boiler up until it burst.

Machine Shop (81). A twelve horse-power engine exploded in Krele's machine shop, Ottawa, Ohio, on May 8th, which threw the engine and boiler 200 feet. A new two-story frame building was entirely wrecked. "The boiler was rotten," says the account. "There were but sixty pounds of steam and plenty of water. The explosion shook the whole town, and threw the engineer, a mere boy, quite a distance." No one else was injured. The loss is estimated at $3,000.

Steamboat (82). By the collapse of a boiler flue on May 11th, on board the St. Louis & Mississippi Valley Transportation Company's steamer *My Choice*, twenty-five miles above Cairo, Ill., on the Mississippi River. Dick Slossenger and James Lawrence, white, and James Arnold, black, were scalded and drowned. Thomas Gorman, watchman, had his hip dislocated, and Nick Cahill was seriously scalded, and James McDonald was badly burned. After floating two miles with the current, her big anchor dragging, the vessel was finally landed at Salidin Towhead.

Steam Launch (83). We have received a very entertaining account of an explosion off the coast of British Columbia (near Vancouver), on May 11th, which we print in full: "The steamer launch *Nagasaki*, built in Japan about a year ago for Captain Steers of this city, has been so injured by an incompetent engineer that it will cost over $1,500 to repair her. The regular engineer refused to go on a voyage with Captain Jones, whom he claimed was not competent. A substitute was taken on; and when some forty miles out of port, the engines suddenly stopped. It was then that he found that he had let the water out of the boilers, and in keeping up the big fires had completely burned out the boilers, *melting the iron, which ran all over the engines*. The tug *Etta White* towed the *Nagasaki* to port, and the engineer took to the woods, and has not been heard of since. His name is Robert Barron." We never heard, before, of a boiler melting and running all over the engines. This explosion ought to have been deferred until the Fourth of July.

Steam Shovel (84). James Kennedy, a contractor in charge of the steam shovel engaged in loading cars with gravel on the Pittsburg bluffs, near St. Louis, Mo., was badly injured by the explosion of the boiler on May 11th. The account says that the engineer in charge "had placed a quantity of powder in the boiler to clean it out, and it exploded." Fragments of the boiler were scattered in all directions. Mr. Kennedy was severely scalded and cut. Two workmen named McGinnis and Murphy were also slightly injured. The scene of the accident is seven miles from East St. Louis, on the Louisville, Evansville & St. Louis Air Line railroad.

Saw-mill (85). By the explosion of a boiler, on May 13th, in G. W. Wilson's saw-mill at Wilson's station, near Germania, W. Va., three men and a boy were instantly killed, and two others were seriously burnt.

Foundry (86). A boiler in Ed. and James O'Rourke's foundry, near New Orleans, La., exploded on May 16th, while it was being tested. The foundry yard was wrecked, and the boiler was carried 100 feet and went through a brick wall. Ed. O'Rourke, one of the proprietors, and Frank Helm, an employe, were fatally hurt. This is, no doubt, another instance of the testing of a boiler by steam pressure. Such an experiment is very dangerous, and we often read of just such disastrous results.

Saw-mill (87). A boiler at Duffy & Simmons' mill at Love Creek, near Boulder Creek, Cal., exploded on May 19th. The mill is a wreck, but no lives were lost.

Mine (?) (88). A boiler in the engine-house at Lyon Mountain, Clinton county, N. Y., burst on May 27th, wrecking the building and three other boilers, and injuring three men, two of them seriously.

Saw-mill (89). A boiler in P. E. Kramer's saw-mill, Frankfort, Mo., exploded on May 28th. Frank Hall and Ed. Kuntz were killed; Glenn Swearinger, William Davis, and two sons of Engineer Hall were fatally injured, Harvey Hutchinson and Ben. Keys dangerously hurt, and an engineer and fireman on a passing train painfully hurt by flying bricks. The mill is a complete wreck.

Tile Yard (90). The boiler in Richert's tile yard, St. Clement's, Ont., exploded on May 28th, killing two boys, Mickers and Richert, the latter a son of the proprietor.

Saw-mill (91). A large boiler owned by William Dean exploded near Clarksville, Ga., with appalling results on May 28th. Pink Hutchins was instantly killed by a piece of the boiler, and a man named Brown was seriously scalded. The boiler was running a large saw-mill, located in a mountain cove with a plank shed built over it. The boiler tore the shed down, "leaped through the air ninety yards like a reckless cannon ball," struck a hickory tree that was thirty-six inches in circumference, and shivered it to pieces as if it been struck by a powerful stroke of lightning. The explosion was heard ten miles way.

Saw-mill (92). A little settlement ten miles west of Menomonie, near Oshkosh, Wis., was the scene of a terrible boiler explosion on May 28th. A boiler running a forty-horse power saw-mill engine burst, instantly killing the proprietor of the mill, L. Kinnett, and also his son, James. The boiler was an old one, and at that time it was carrying eighty-five pounds of steam. The mill was not running, having stopped for a few moments for slight repairs. The explosion was terrific, literally blowing the boiler to fragments. One piece, weighing 1,500 pounds, was hurled high over the trees twenty rods away. L. Kinnett was a man of sixty-four years, and his son was twenty-two.

Ice Factory (93). On May 31st, a manhead in one of the boilers in the Consumers' Ice Manufactory, on Magazine, between Julia and Girod streets, New Orleans, La., was blown out, causing a damage of about $50 to the boiler. An employe named Charles Reamer was struck by a piece of the flying manhead and painfully wounded over the left eye.

Brewery (94). On May 31st, a boiler explosion occurred in the malt-house of the Portsmouth Brewing Co., Portsmouth, O., which may cost the life of George Rettinger, who was seriously burnt. The boiler was located in the northwest corner of the building, and it took the entire end of the structure with it. It passed through the air with terrible force, landing about 500 yards from the scene of the accident, in a yard on Third street. Almost the entire population visited the scene, and congratulated the occupants of the house on their escape from injury.

Saw-mill (95). We learn from the Salt Lake City *Tribune* that a boiler explosion in a saw-mill at Vasquez, on April 8th, resulted in the death of a man named Miller, and in fatal injuries to two Mexicans. (Received too late for insertion in the proper place.)

June, 1891.

Saw-mill (96). A terrible accident, resulting in the death of five men and the wounding of eight others, all dangerously, occurred in J. L. Jordan's saw-mill near Bowling Green, Caroline County, Va., on June 1st. The men were at work near the engine-room, when the boiler burst, and they were caught in a shower of missiles and scalding water, several of them being buried out of sight in the ruins. The uninjured employes hurried to their rescue, medical aid was immediately summoned, and everything done to relieve the injuries of those taken out alive. The killed are: William Seef, Lawrence Hayes, William James, John Fry (colored), Weseam Catlett. Seven other colored men and one white were rescued alive, but their injuries are so serious that all may die. The cause of the explosion, which completely wrecked the mill building, has not been definitely ascertained.

Government Cruiser (97). An explosion occurred June 2d on the new cruiser *Concord*, which was on her way from Washington to Norfolk. A steam-pipe burst, causing the death of a fireman and coal-heaver. Several other persons were injured.

Saw-mill (98). A boiler explosion occurred at Dusard Bros. saw-mill, near Fayetteville, Ind., on June 3d, which will cost five men their lives. Two of them, named Evans and Kern, died inside of an hour. The other three cannot possibly live. One of them, the son of John Dusard, one of the owners of the mill, had both legs broken, and was injured otherwise. Another had his skull crushed.

Steamer (99). An accident occurred on June 5th near San Diego, Cal., on board the steamer *Manuel Dublan*, which will probably prevent that vessel from sailing the seas for some time. During the visit of the inspectors and while the boilers were being inspected, a pressure of steam was turned on which proved too much for the boilers to stand, and when the pressure reached 140 lbs. they burst. No one was injured.

Rolling-mill (100). On the morning of June 6th one of the boilers in the muck mill of the Briggs rolling-mill, situated in the eastern part of Findlay, O., let go with a loud report, shaking up things lively in the immediate vicinity, but fortunately no lives were lost. An engineer was in the building but escaped with a few bruises. The wrecked building caught fire, and completely burned down. The fire department saved the other buildings. The loss, it is said, will foot up to many thousand dollars.

Repair Shop (101). A boiler explosion occurred in Reed & Beil's repair shop on Main street, Galena, Iowa, a few minutes after 3 o'clock on June 8th, wrecking things generally in the shop and causing fatal injuries to Chas. Beil, the son of Adam Beil, one of the proprietors.

Portable Boiler (102). There was a terrific boiler explosion on A. Menke's ranch, a short distance beyond Perkins Station, near Sacramento, Cal., on June 8th. A pump had been placed in position beside the American river with which to raise water to irrigate the hop field, and an engine and threshing-machine boiler of the largest size was to furnish the power. Just as everything was in position and a fire built, the dinner bell sounded, and Mr. Menke ordered the crew to lunch. The fire was "banked," and after a hurried dinner all started back for the engine. Mr. Menke and son William were in a buggy and took the lead. When within a short distance of the pumping-works they stopped to water their horse. This undoubtedly saved their lives. They were looking toward the boiler when, without a moment's notice, it exploded, and with a force that surpasses belief a portion of the boiler cut off a tree more than a foot in diameter, as smoothly as though done with a saw. The main portion of the boiler, weighing several tons, was hurled a distance of two blocks. A large box of tools and many timbers were blown into the river, and the irrigating troughs were wrecked for some distance. Had the explosion occurred two minutes later, after the men had congregated about the boiler, there would certainly have been an appalling loss of life.

FURNITURE FACTORY (103). Shortly after noon on June 13th a boiler explosion occurred at Theodore Kraan & Brothers' furniture factory, northeast corner Sixth and Master streets, Philadelphia. The report of the explosion could be heard several squares, and caused much excitement in the neighborhood. Luckily, however, the mill had shut down a few minutes before the explosion, and nearly all the employes had left the building. John Dryer, the engineer, who was at work on the fires, was thrown to the ground and badly burned about the neck and face. Dennis Donovan, who happened to be in the building at the time, was also badly hurt and burned about the body. A few minutes after the explosion the flames communicated with the two-story brick dwelling in the rear of the factory, and in a few minutes the entire structure was in ruins. The loss was estimated about $10,000.

PORTABLE BOILER (104). A portable engine used by the Akron Water Works company, Akron, O., as a drill engine, a quarter of a mile from the pumping station, exploded at noon on June 18th, instantly killing Henry Golden, fatally injuring John Harvey, and seriously injuring Clarence Felton, Newton Ramey, Frank Jackson, James Mowder, J. Benj. Huffman, and James Farabee.

PORTABLE BOILER (105). A portable boiler standing in the Southern Boulevard near Home street, New York city, exploded on June 18th. Michael Orsini, a watchman for John Cornell, who owned the boiler, was sitting up over it, and was seriously injured.

BLAST FURNACE (106). On June 19th there was a disastrous boiler explosion at Martin's Ferry, near Wheeling, W. Va. Considerable damage was done, and Charles Roush was killed. His father, George W. Roush, and Robert Glenn, were injured. A full account of this explosion will be found in the July issue of THE LOCOMOTIVE.

HEATING BOILER (107). What might have been a serious accident occurred at the Niagara University, Suspension Bridge, N. Y., on June 20. The crown sheet of the boiler used to heat the University buildings blew out with great force. Engineer Ernest Dovey was working in front of the boiler and was severely burned about the face and hands. The property loss was not great.

COAL MINE (108). A frightful boiler explosion occurred on June 21st at the Drake coal company's mine, two miles west of Massilon, O. The engine and boiler were completely wrecked, and the buildings occupied were destroyed by the fire, which succeeded the explosion. Henry Vogt, the night engineer, who was alone on duty, was killed and his body consumed by the fire. The property loss is said to be $2,000.

BRICK-YARD (109). The boiler at Adams' brick-yard, in the southern suburb of Indianapolis, Ind., exploded at 1 o'clock on June 22d. Peter Haskins, the colored engineer, was scalded to death. The building was totally wrecked, not one brick being left in place. It is claimed that the boiler was carrying only seventy-five pounds of steam, and that the gauge showed plenty of water.

LOCOMOTIVE (110). A locomotive explosion occurred on the Central Railroad of New Jersey, on June 29th, near Nesquehoning Junction, by which four men were instantly killed. Yard engine No. 235 was shifting freight, and had just passed out of the yard, in which there were several other locomotives and crews. When it reached Nesquehoning a leak was noticed in the furnace. Fireman Pope got down from the cab to examine the boiler, and instantly a violent explosion occurred. The four men who were on the engine were blown in every direction. The killed are: Engineer Thomas

Tripp, Fireman J. Pope, Brakeman Gallagher, Brakeman Smith. The body of Engineer Tripp was found more than one hundred yards away. His body was bruised and crushed. The brakemen were found in an opposite direction, and must have died almost instantly. The engine was totally wrecked, the boiler landing upon the mountain fully 300 feet from where it had stood.

The First Landing Place of Columbus.

The Chicago *Herald* publishes a long article giving the results of the expedition which it sent out a month ago to find and mark with a monument the spot at which Christopher Columbus first landed on the shores of the new world, October 12, 1492. The expedition met with success. At Nassau, the capital of the Bahamas, Governor Shea gave the expedition a letter of authority, calling upon all local magistrates to give every assistance in their power. The steamer *Nassau*, the largest steamer in the Bahamas, was chartered for the cruise, and it left Nassau June 9th.

Five islands have been suggested as the scene of the discovery, — Cat Island, which for many years was marked San Salvador on the maps; Watling's, Samana, Mariguana, and Turk's Island. All but two of these (Watling's and Samana) have been virtually discarded by modern geographers and historians. The journal or log-book of Columbus is the only historic evidence there is of the landing place.

From the first moment, evidence that Watling's Island was the true San Salvador appeared on every hand. None of the previous writers or investigators in the field had taken the pains to do that which the *Herald* expedition did — visit the spot in person, and apply the historic evidence, that of Columbus himself, to the physical features of the island. In this way the Chicago explorers were able to find new and convincing proof of the identity of Watling's Island with the San Salvador of the great discoverer. In fact, the evidence is so strong as to be indisputable. It is far beyond the range of the probable that at any other point there exist, one beside the other, such a harbor and such a headland, answering in every particular, both as to themselves and as to their relative positions in an island, which also meet every requirement of Columbus's description of his San Salvador.

These and hundreds of other considerations induced the *Herald's* expedition to erect its monument on the northeastern shore of Watling's Island, on a headland overlooking the little sandy beach bay in which Columbus landed. More than a score of workmen were engaged building the monument. Fortunately, an ample supply of coral limestone of beautiful colors and picturesque shapes was found on the headland. The monument rises sixteen feet from its foundations. Six feet from the level of the ground in a pretty grotto, built for the purpose, is a marble globe, nearly two feet in diameter, with an outline of the continents chipped upon the surface. A silver star marks the site of Chicago, and another star marks the true San Salvador of Columbus, — Watling's Island. Below the globe is a marble tablet on which is carved: "On this spot Christopher Columbus first set foot upon the soil of the New World. Erected by the Chicago *Herald*, June 15, 1891."

The monument was dedicated at four o'clock in the afternoon of June 15th, with short but appropriate ceremonies. An incident of the building of the monument was the placing within the foundations of portraits of the great editors of the United States, and copies of a number of leading American newspapers, making the structure, in a sense, a newspaper offering to the memory of the great discoverer. — *N. Y. Observer*.

The Locomotive.

HARTFORD, AUGUST 15, 1891.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

THE twentieth annual report of the *Schlesischer Verein Zur Ueberwachung von Dampfkesseln* is at hand; also the eighteenth report of the *Sächsisch-Thüringischer Dampfkessel-Revisions-Verein* of Halle, and the report of the eighteenth regular meeting of the Hannover *Verein Zur Ueberwachung der Dampfkessel.*

MESSRS. John Wiley & Sons, of 53 East Tenth Street, New York, send us a copy of W. E. Hall's little book on *Car Lubrication*, which we have read with interest and profit. Mr. Hall discusses Woodbury's and Tower's experiments on the resistance of lubricants, and then proceeds to consider bearing metals, methods of lubrication, journal-box construction, and cost of lubrication, and the final chapter is devoted to the cause and treatment of heating.

SIGNOR Francesco Sinigaglia has kindly favored us with a copy of his *Instruzioni Pratiche pei Fuochisti*, published at Rome. It is an interesting volume of 118 pages, relating to the newly formed association for the supervision of steam-boilers, of which Signor Sinigaglia is chief engineer. The first part of the volume is addressed especially to the owners of steam-boilers, and contains useful suggestions concerning the management of steam-boilers, and directions to be followed in case of emergency.

IN the June issue of THE LOCOMOTIVE we published a cut of a boiler that exploded on account of a blind gasket in the steam pipe. A correspondent asks if this explosion may not have been caused by the equalization of pressure through the mud-drum of the battery, the water in the boiler with the gasket being forced into the others by the accumulating steam above it. In that case, the boiler having no water in it, the fire in the furnace would rapidly burn the iron, of course, and destroy its strength.

In reply to our correspondent we beg to say that the action he suggests is a well-known source of trouble in boilers having a mud-drum in common; but that in the present case the exploded boiler was put in after the other three boilers in the battery, and we understood that it had a *separate* mud-drum, so that the action in question could not take place. We have since ascertained that the mud-drums were *not* separate; and the explosion was no doubt brought about in the manner indicated above.

We never advise setting boilers with a mud-drum in common.

Mr. A. S. Ferry, who has been connected with the home office of this company for several years, has been put in charge of our Northern Ohio department, to fill the vacancy caused by the death of Mr. Geo. P. Burwell.

Signaling to other Planets.

It is said that a French nun has bequeathed 100,000 francs ($20,000) to the Academy of Sciences, to be given as a prize to any one who shall discover a means of communicating with another planet or star. The planet Mars was suggested in the will as the most convenient heavenly body on which to make the experiment.

The subject of the possible plurality of worlds has always been a fascinating one. Many people maintain that it is improbable that so many heavenly bodies have been created suitable for the abode of intelligent beings, unless there are intelligent beings there. Some have even pointed to John x. 16, as testimony from Christ, that there are other worlds peopled with human creatures, to whom He must also go. We are not prepared to give an authoritative explanation of this passage, and must leave each reader to judge it for himself. It is pretty certain, however, that Mars either is now adapted to the wants of intelligent creatures, or has been in the past. A great deal of very interesting information concerning this fiery neighbor of ours has been picked up by astronomers, and there are good reasons for believing that many of the conditions that exist on the earth, exist also on Mars. It is true that the so-called "canals" recently discovered on the planet, indicate a state of affairs different from those observed on the earth; but until the cause of these curious markings is ascertained, it would be premature to conclude that the Martian world is entirely different from ours. Markings somewhat analogous to those on Mars are seen on the moon, where they appear to be due to the withering up of our ancient satellite's surface; and the markings on Mars have been brought forward as evidence of the decrepitude of the planet, the assumption being that they are due to the same cause as the lunar "rays" or striæ, or to a similar cause. This does not seem probable to us, for the markings on the moon are permanent and unchanging, while those on Mars appear to be variable.* If we cannot assume the "canals" to be of a nature similar to the lunar "rays," it is difficult to guess what their nature is. Various theories have been proposed, but none of them are satisfactory. It has been assumed that they are of artificial origin, and that they subserve some useful purpose in the commerce of the peoples there. This proposition seems extravagant, however, on account of their size and apparent variability; yet we cannot say that it is not so. Again, we may assume them to be intended for the very purpose of signaling to the earth. In such a case their variability could be easily understood, for no doubt such works would be of an unsubstantial nature, the expense of constructing them being enormous, even then.

Various suggestions have been made in past times, for establishing communication between the earth and other celestial bodies. The best suggestion we know of, was that of a Frenchman, who proposed to go to the steppes of Siberia and construct a gigantic copy of the figure which Euclid uses to prove that the square on the hypothenuse of a right-angled triangle is equal to the sum of the squares on the other two sides. He reasoned that any creatures who are intelligent enough to construct telescopes capable of showing this figure, must have already discovered this property of the right-angled triangle, and would recognize the diagram at once as an artificial production. They would no doubt reason that our knowledge of geometry is pretty well advanced, since we

* For evidence of this variability see Schiaparelli's articles in *Himmel und Erde* for October, 1888, *et seq.*

would naturally select a familiar theorem, in order to make sure that they would recognize it. It has occurred to us that the Martian markings may be laid out for our benefit, with precisely the same idea in view. We do not advance this as a probable supposition, but merely as a possible one, worth examination. The question arises at once, Do the Martian markings illustrate any of our known geometrical theorems? We have carefully examined Schiaparelli's drawings to see if any such correspondence can be traced, but thus far we have found nothing. It seems possible, from the arrangement of the lines, that some theorem in higher or projective geometry may be discernible, say some property of intersecting pencils of rays; but we can find nothing at all conclusive, and no doubt the idea will have to be given up.

In case it should be decided that the markings on Mars are for signals to the earth, we should find it difficult to return an answer, for when we are nearest to our neighbor we see his bright side, and he sees our dark side. We should, therefore, have to signal back by means of an arrangement of bright points, visible in Mars. Now it would take a group of powerful electric lights some miles in diameter to be visible at such a distance with any telescope at our command at present. May we not assume, however, that Mars, being further from the sun than we are, is also older, and that such intelligent creatures as may exist there are likewise more advanced than we are? And if so, may they not have better and more powerful telescopes, and be able to study the earth's surface when a part of the illuminated portion is visible? Assuming that this is the fact, a method of signaling occurs to us which need not be excessively costly in the end. We might sow vast fields with grain of some distinctive color, arranging the planted areas so as to form any desired geometrical figure. The yield of grain from such fields would pay a considerable portion of the expense of the undertaking, and the enormous increase in production would so lessen the cost of food that famine would be unknown while the astronomical signals were continued.

The Wave Theory of Sound Again.

The advocates of the so-called "substantial theory" of sound still seem to have difficulty with tuning-forks. One of them says he defies any one to perform the experiment of producing silence by the combination of two sounds. We have often tried it with success. But the principal trouble now seems to be with the tuning-fork, and Prof. Henry A. Mott calls attention to it in a recent article in the *Scientific American Supplement*. In his article we find the following passage: "Tyndall says, 'when a common pendulum oscillates, it tends to form a condensation in front and a rarefaction behind, but it is only a *tendency;* the motion is so *slow*, and the air so elastic, that it moves away in front before it is sensibly condensed and fills the space behind before it can become sensibly dilated. Hence, waves or pulses are not generated by the pendulum.' Helmholtz says, 'The pendulum swings from right to left, with a uniform motion. Near to the end of its path it moves slowly, and in the middle fast. Among sonorous bodies which move in the same way, *only very much faster*, we may mention tuning-forks.' Tyndall also says, 'The prong of the fork in its *swift* advancement condenses the air.' And Sir William Thomson says, 'If I move my hand *vehemently* through the air, I produce a condensation.' It is perfectly evident, then," says Dr. Mott, "according to the supporters of the wave theory, that to produce a 'well-marked' compression, the motion of the vibrating body must be 'faster' than the motion of the pendulum, and, in fact, must be 'swift' or 'vehement' motion. Now, if it can be shown that while the tuning-fork is still producing sound, and, in fact, sounding audibly, the motion of the prong is not 'swift,' 'vehement,' or 'faster' than the motion of a pendulum, but exceedingly 'slow' motion, having a velocity at its swiftest point of only about 14.9 inches in five minutes, then surely the learned supporters of the wave theory will willingly admit that no 'well-marked' condensation can be formed, and consequently no sound could be produced. . . . Now the facts are that the actual distance the prong of a C_3 tuning-fork of 256 full vibrations travels when first bowed is about $\frac{1}{15}$ to $\frac{1}{20}$ of an inch, and that if actual measurements are made after it has been sounding for over a minute, the actual distance of its travel will be found to be $\frac{1}{17000}$ of an inch, and as it makes 256 full vibrations, the actual distance the prong travels in one second will be $\frac{512}{17000} \times 1.5708$ (correction obtained by comparing the conical and reciprocating pendulum), or 14.9 inches in five minutes, and still the tuning-fork continues to sound audibly for five minutes, and the distance the prong travels over still continues to diminish."

We quote Dr. Mott at some length, because his argument is an ingenious one, and to some minds would be conclusive. The quotations he makes are mostly from text-books or from popular works on sound. The only exception to this that we notice in connection with the present subject, is the quotation from Helmholtz, which we find on p. 19 of his *Sensations of Tone*, in the early and simpler part of the book. We wonder if there is not some significance in this? Text-books and popular works cannot be expected to have the precision that would be found in a standard work on sound, like Donkin or Rayleigh. Why not occasionally give us a problem suggested by passages in these or other equally good books?

Now it must be admitted that the phraseology in some of the foregoing quotations is not all that could be desired. For example, in the passage quoted from Helmholtz the word "quicker" could have been substituted for "faster" with distinct advantage. In fact, it ought to have been plain to Dr. Mott that "quicker" was intended, for the quotation that he gives continues thus: "When a tuning-fork is struck or excited by a violin bow, and its motion is allowed to die away slowly, its two prongs oscillate backwards and forwards in the same way and after the same law as a pendulum, *only they make many hundred swings for each single swing of the pendulum.*" It is the frequency of the vibrations, and not their amplitude, that determines whether the vibrating body is sonorous or not. Similar alterations of phraseology might be made in some of the other quotations, so as to make the meanings more perspicuous. In Helmholtz's case we imagine that A. J. Ellis, the translator, was responsible for the lack of precision.

Let us admit Dr. Mott's figures, and look at the tuning-fork problem from another point of view. Suppose his fork is placed under a microscope and magnified 17,000 diameters, so that the amplitude would appear to be one inch, instead of $\frac{1}{17000}$ of an inch. The breadth of the fork (say half an inch in reality) would then appear to be 708 feet. Now, does Dr. Mott imagine that air would flow freely around a body an eighth of a mile square, vibrating 256 times a second with an amplitude of only one inch? Surely not. The air in front of such a body would certainly be compressed, and a wave of compression (that is, of sound) would spring forth from it.

Of course, the actual case is different. We understand that perfectly. The illustration was given only to show the nature of the solution of Dr. Mott's difficulty. Air is not an imponderable substance. A cubic yard of air weighs over two pounds. It is instructive to measure out a cubic yard of it, and then take a two-pound weight in one's hand and think. The disturbance that would take place in such a medium, when it is acted upon by a tuning-fork, can be determined in only two ways: first, by direct observation, which is impossible in the case of a fork whose amplitude of vibration is only the 17,000th part of an inch; and second, by a mathematical analysis of the motion of an elastic, compressible fluid, when subjected to a periodic disturbance of given frequency and character. If Dr. Mott (or Dr. A. Wilford Hall) wants to find out whether a tuning-fork will produce sound waves or not, he must either study up differential equations and the laws of fluid motion, or accept the statements of others who *have* studied up these things. At all events, let him cease to imagine that such elementary difficulties have not occurred to such profound thinkers as Sir William Thomson, and been answered.

There is one other thing in the wave theory of sound that disturbs our friends, the "substantialists." Newton's formula for the velocity of sound in a body does not give the correct result when the body is gaseous, and it is found that in such cases the velocity as found by his formula has to be multiplied by the square root of the ratio between the specific heats of the gas at constant pressure and at constant volume. Dr. Hall in particular seems to be troubled by this. He is ready to admit that the elasticity of the compressed part of a wave would be increased by the heat set free by the compression, and that the velocity of sound would therefore tend to be greater than it would be without such compression; but he points to the fact that although the compressed part is heated and its elasticity increased, the rarefied part is cooled and its elasticity is diminished; and he cannot see why the two effects do not neutralize each other. If he will read Rankine's paper on "The Centrifugal Theory of Elasticity," published in the memorial volume of his writings, he will find there a general proof of the proposition, which we venture to say will satisfy the most incredulous.

Writers on the theory of sound are not dishonest or stupid, as Dr. Hall seems to think. They are just as ready to hunt up any weak points in their theories as he is himself; and if he will read up the mathematical papers that have been written on sound, he will find that rigorous proofs of all these knotty points have been given.

A New Atlantic Record.

On Wednesday, August 5th, the White Star Line steamer *Majestic* reached New York with a new record. Her time from Daunt's Rock lightship, off Queenstown harbor, to Sandy Hook lightship, off New York bar, was five days, eighteen hours, and eight minutes. The best undisputed time previously made was that of the *City of Paris*, on the trip ending August 28, 1889, her time from Roche's Point to Sandy Hook being five days, nineteen hours, and eighteen minutes. The friends of the *Teutonic* claim for her a record of five days, nineteen hours, and five minutes, in August, 1890; but this record is disputed.

At 11.50 A. M., on Wednesday, July 29, the last bag of American mail was hustled on board at Liverpool, and less than four hours later the *Majestic* was passing Rock Light, bound for Queenstown. At 6.30 the next morning she dropped anchor in Queenstown harbor, having covered 236 miles. She waited until afternoon for the mails and for belated passengers, and at two o'clock P. M. the race for a new record began. The weather was perfect and the ocean calm, and 470 knots were covered in the first twenty-four hours. In the twenty-four hours ending on Monday, August 3d, the *Majestic* had covered 501 knots, and had covered 1,969 knots altogether, so that she had only about 800 more before her. On Monday afternoon she met the first steamer seen on the trip — one of the North German Lloyd line.

Next day one of the engines had to be stopped for an hour and a half, so that only 491 knots were made. This brought the *Majestic* off the coast of Nantucket. On Tuesday night many of the passengers remained on deck very late, and long before midnight

Shinnecock light was passed, eighty miles from Sandy Hook. At precisely half-past two on Wednesday morning the lightship was abeam, the race was ended, and a new record had been made.

"There are some interesting figures connected with this passage," says the New York *Sun*. "The Inman liner, *City of Paris*, in her August voyage, 1889, traveled 2,788 miles in 8,358 minutes. The *Majestic* traveled 2,777 miles in 8,288 minutes. In time, the *Majestic* is seventy minutes ahead. In speed, the difference between the ships is less because of the distance traveled. It appears that on an average the *City of Paris* traveled a nautical mile in 2.998 minutes, while the *Majestic* covered her mile in 2.984 minutes, so that she was .84 of a second faster. The *Majestic* averaged 20.107 knots an hour. One feature of the passage of the *City of Paris* is still unequalled. On August 25, 1889, she covered 502 knots; on the 26th, 506 knots; and on the 27th, 509 knots."

During the *Majestic's* passage her engines exerted 19,500 horse power, making, on an average, 78 revolutions a minute, with a consumption of 220 tons of coal a day — an unusually small amount.

The accompanying table gives the knots logged per day by the *City of Paris*, the *Majestic*, and the *Teutonic:*

Days.	Majestic.	City of Paris.	Teutonic. (Disputed.)
First, ...	470	432	473
Second, ...	501	493	496
Third, ...	497	502	512
Fourth, ...	501	506	500
Fifth, ...	491	509	485
Sixth, ...	317	346	340
All six, ...	2,777	2,788	2,806

A CORRESPONDENT writes to the New York *Sun* concerning Pizarro as follows: The accounts transmitted from Lima of the exhumation and reinterment of the remains of the conquerer of Peru are very interesting. Of course the identity of the remains will be disputed. It always is in such cases. But many circumstances concur to show that the remains which have just been relaid at rest with so much pomp in Lima are in all probability those of the great conquerer. We are told that an "indentation" was found on the skull which is supposed to have been caused by "a blow with a silver jug full of water." I know not, of course, what ground there may be for supposing that Pizarro was ever struck on the head with a silver jug full of water. But a blow which "indented" the skull must have had a serious effect on the recipient, and I think it much more likely that the indentation in question testifies to the accuracy of a contemporary account of his assassination which, thanks to Padre Vigil, I had the pleasure of reading at the then excellent public library of Lima nearly twenty years ago. This public library, I have been informed, was pillaged and looted by the Chilians, and its most valuable contents carried off to Santiago, where they are, I hope, carefully preserved in the university library of that capital. The account to which I refer was contained in a large quarter manuscript of the middle of the sixteenth century, with marginal references. I was permitted to make many extracts from it, which I still possess. Pizarro was murdered in the street at the entrance of a *zaguan* just off the Plaza of Lima on the 26th of June, 1541, and after dusk. According to the account to which I refer, his assassins lay in wait for him about nine o'clock in the evening and struck him down noiselessly from behind "with a long stocking filled with wet sand," or, in other words, with what in modern times has been known as a "sand bag." Such a weapon would in all likelihood have beaten in the skull and left its trace in the indentation described in your despatch. If the manuscript to which I refer escaped the search of the Chilians for literary treasure, some Peruvian scholar may be able to find it still in the library of Lima.

The Locomotive.

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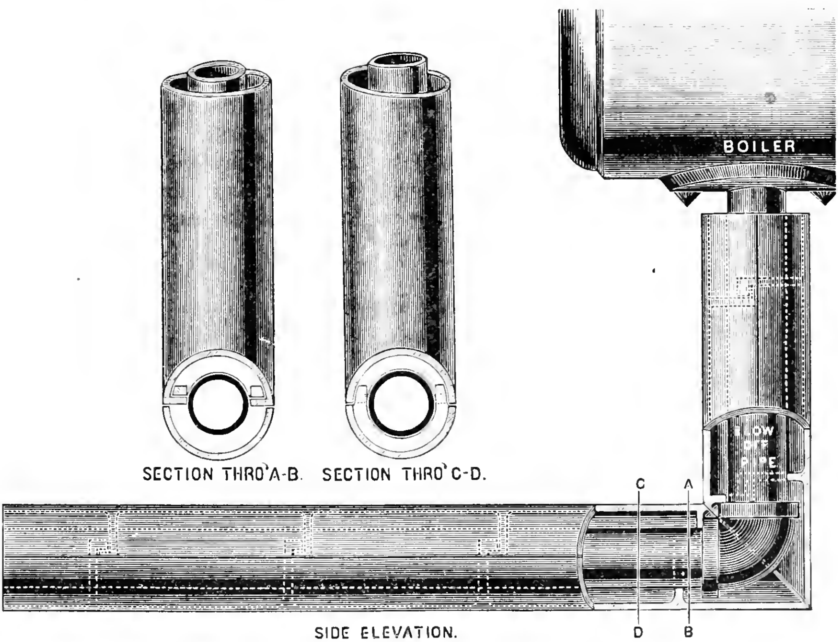
Blow-off Pipes.

Among the defects reported by our inspectors many defective blow-off pipes occur, and accidents often arise from this source. The defects are usually due to the burning of the pipes. When sediment is present in the feed water, the pipe becomes partially filled with it, and overheating is the result; and even when the water is pure, the high



CAST-IRON COVERING FOR BLOW-OFF PIPES.

temperature to which the blow-off pipe is exposed seems to cause the water to attack the iron, and deterioration may be quite rapid.

Much of this trouble seems to be due to the flame striking directly against the pipe, and to overcome it, it is customary to slip a cast-iron sleeve over the pipe to protect it. A piece of soil pipe is the usual thing for this purpose. This in turn becomes burned away, and to replace it, it is necessary to disconnect the blow-pipe and run it through the new sleeve. To avoid this trouble, half sleeves with lugs or flanges, fastened together by bolts, have been used, but these have not proved perfectly satisfactory, as the projecting lugs are apt to burn away after a little while.

Steam users have often asked our inspectors for something not expensive, which could be put on without disconnecting the blow-off pipe, and some years ago we made drawings for a sleeve having supporting rings with lugs so arranged that the two halves could be securely fastened together without bolts or nuts. The details of the sleeve will be seen from the cuts. Inside of the sleeve half rings are cast, the internal radius of which is slightly larger than the blow-off pipe. At the ends of these half rings hook-like lugs are cast, which serve to fasten the parts of the sleeve together. In putting this covering on, one-half of it is first laid against the pipe, and the other part is brought down upon it with one end hanging half or three-quarters of an inch over the end of the first half. The two are then slid together until the hooks or lugs inside lock together. The dimensions of the sleeve may be altered at will, but we have recommended the following for a two-inch blow-pipe: Diameter of cast-iron sleeve internally, $3\frac{7}{8}$ inches; thickness of casting, $\frac{1}{4}$ inch; distance from one supporting ring to the next, 8 inches. The ends of the horizontal and vertical lengths are, of course, beveled so as to fit together, and care must be taken that the lugs or hooks that secure the parts together do not come within, say, an eighth of an inch of the blow-off pipe or the sleeve itself, as otherwise the parts will be likely to become iron-bound under the intense heat to which they are exposed. If the brick-work is so arranged that a small amount of air can enter the sleeve, a circulation can be maintained through it that will give further protection to both sleeve and blow-off. The rings in the sleeve will prevent the air from drawing freely through, but it will be found that enough will pass by them to be of benefit.

We believe this arrangement has proved satisfactory, and any one wishing to use it can make a pattern, one pattern being sufficient if it is made long enough, since shorter pieces may be cast by simply cutting off in the sand mould to the length desired.

Inspectors' Reports.

JUNE, 1891.

During this month our inspectors made 6,044 inspection trips, visited 11,405 boilers, inspected 5,106 both internally and externally, and subjected 703 to hydrostatic pressure. The whole number of defects reported reached 11,196, of which 1,110 were considered dangerous; 33 boilers were considered unsafe for further use. Our usual summary is appended:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	890	41
Cases of incrustation and scale,	1,306	49
Cases of internal grooving,	56	7
Cases of internal corrosion,	494	16
Cases of external corrosion,	687	39
Broken and loose braces and stays,	146	35
Settings defective,	281	26
Furnaces out of shape,	363	24
Fractured plates,	182	41
Burned plates,	206	26
Blistered plates,	282	12
Cases of defective riveting,	2,375	129
Defective heads,	73	10

Nature of Defects.	Whole Number.	Dangerous.
Serious leakage around tube ends,	2,252	486
Serious leakage at seams,	452	39
Defective water-gauges,	287	45
Defective blow-offs,	150	22
Cases of deficiency of water,	15	5
Safety-valves overloaded,	49	10
Safety-valves defective in construction,	71	18
Pressure-gauges defective,	402	27
Boilers without pressure-gauges,	3	3
Unclassified defects,	174	0
Total,	11,196	1,110

Boiler Explosions.

July, 1891.

Foundry (111). The boiler belonging to Allan & Sons' foundry and machine shop in the west end of Collinsville, Ill., exploded July 1st. Fortunately no lives were lost, though there were a number of mechanics employed on the repairs of threshing engines near the scene of the explosion. A piece of casting weighing 30 pounds was blown 200 yards, embedding itself in the wall of a brick house. Mr. George Kalbfleisch was scalded, but not seriously. A woman who was washing clothes a block distant from the wreck was struck by a piece of the boiler, but only slightly injured.

Locomotive (112). The engine of a freight train on the Norfolk & Western railroad exploded on July 1st, near Ford's depot in Dinwiddie county, Va., causing considerable damage. The engine was wrecked, and a number of cars were derailed and piled upon one another. Engineer Thomas Andrews, of Petersburg, was scalded about the head and face. and a negro boy who was stealing a ride was quite badly scalded. A tramp was also scalded.

Sand Boat (113). The boiler of the new sand sucker *Laura D.*, belonging to P. & T. Degnan, exploded near Toledo, O., on July 3d, badly scalding the engineer and fireman. The accident happened while the boat was about half-way between the black can and the crib lights, returning with a load of sand. The steam scalded the fireman, Wm. Heemroth, very badly about the face, hands, and legs. Although his injuries are very serious he will recover. The engineer, Bert Ransom, was severely scalded about the face and hands, but is able to be about. The *Laura D.* is a new sand boat, having been launched last April.

Soap Works (114). On July 8th a boiler used in Moulson's soap factory on Water street, Rochester, N. Y., exploded and made a general wreck of the woodwork around it. The boiler was employed in rendering fat, and carried fifty-five pounds of steam. It was situated below the street level in a room facing the river, where only a few men were employed. The only one injured was Henry Virkus of Bernard street. His injuries were slight cuts on the face. The windows were blown out of the building and the shock shook the walls, but the damage is less than might have been expected from the situation of the boiler.

Saw-mill (115). On July 10th, the boiler in Greenleaf Johnson Lumber Company's large saw-mill, Norfolk, Va., burst, seriously injuring the two colored firemen. It is thought that one will die.

Threshing Machine (116). On July 11th, a boiler explosion occurred in Bruceville, near Vincennes, Ind., that killed two men, fatally injured another, and wounded and scalded five others. The cause of the accident is not known. It is claimed that that there were only twenty pounds of steam on at the time of the explosion.

Saw-mill (117). By the explosion of the boiler of a mill, on July 11th, on Salt Lick, near Chicago, Ky., Buck Thompson, the owner, was instantly killed, and three other men seriously injured. George Pickerel's wounds are probably fatal. Two sons of Pickerel were seriously scalded. The boiler was an old one, but the cause which led to the accident is not known.

Steam Launch (118). On July 12th, the boiler of the naphtha launch *Ethel* exploded off Coney Island, near New York, and four men were killed. Captain Low White was in charge of the boat at the time, and he saved himself by swimming to a floating buoy, from which he was rescued by a boat from the shore. White was severely bruised, and it is not known whether the other four men were drowned or were killed by the explosion.

Motor Car (119). Late at night on July 12th, a motor on one of the Suburban Rapid Transit Company's cars (Pittsburgh, Pa.), exploded at a point near Whitehall, about five miles beyond the city line. One man was fatally injured, three women had their legs broken, and several other passengers were more or less injured.

Steamer (120). On July 14th, a boiler explosion occurred on the Washington steamer *Jane Moseley*, Captain Frederick Posey commanding. The *Moseley* had been lying at Norfolk, Va., and had just gone over to Portsmouth for the freight. Several of the crew jumped overboard, and some were thrown over by the shock. John H. Cockerell, the night watchman, was seriously and perhaps fatally injured. He was asleep in his stateroom at the time; and when the explosion occurred, he ran out of his room, and was enveloped in the escaping steam. He managed to get to the rail and jumped overboard and swam to the rudder and clung to it until picked up by two men. Assistant Engineer Brady says he was at the starting bar at the time, and was obliged to crawl on his hands and knees out of the engine-room to escape the steam which was pouring down on him. Quite a number of machinists and boilermakers visited the *Moseley* after the explosion, and it was the unanimous opinion that the direct cause of the explosion was that when the vessel was repaired recently, the old drum head had been riveted on to the new shield, and to make the rivet holes agree a drift pin had been used, and many of the old rivet holes had been cracked, thus weakening the boiler. The drum head of the other boiler was also started.

Flouring Mill (121). The head of the boiler in the Reasor flouring mill at West Fork, near Leavenworth, Kan., blew out on July 15th, the explosion tearing away the end of the building, and the water and steam badly scalding Thomas Gregg, the fireman, who was the only one standing near. Mr. Gregg is scalded from head to foot, but there is hope of his recovery.

Threshing Engine (122). The boiler of a threshing engine exploded on July 15th, near Chalfants Station on the Shawnee branch of the B. & O. railroad. The machine was badly shattered, and pieces of the boiler flew in every direction. One man was struck and probably fatally injured, and his body was terribly burned by escaping steam.

Pumping Works (123). On July 20th, one of the boilers in the pumping station at Bridgeport, Ill., exploded, demolishing one end of the boiler-house, but injuring nobody. Mr. Culliton, the chief engineer, ventured the suggestion that there was nothing remarkable about having an explosion or two occasionally, and he went on to say, "These boilers have been in service nine years, working twenty-four hours each day. That is equal to about eighteen years of service. A boiler can be kept in use, without danger of explosion, for about ten years (!) I don't believe any one is to be blamed for this explosion. I am a little over thirty years old, and in my time I have seen over twenty explosions. Not one of them was ever satisfactorily explained (!) The bottom simply dropped out of this boiler, and no living man could have foreseen that there was to be an explosion." However, Mr. Culliton said he didn't know whether this boiler had been inspected lately or not.

Planing Mill (124). A terrible boiler explosion in E. G. Perkins's planing and shingle mill at Lake View, Montcalm county, Mich., on July 20th, killed three men, and injured four others. E. G. Perkins (the owner) and Robert Gregory and his son, Eddie, a boy of thirteen, were hurled a great distance, and died where they fell. Charles Richer and three others were injured. The mill is a wreck, and the bodies of killed and injured were removed from the ruins with difficulty. The dome was thrown 300 feet, and other parts of the boiler were thrown 600 or 700 feet, cutting the telephone wires and injuring building and causing general consternation.

Cotton Mill (125). The boiler at the Manchester cotton mill in Vineville, near Macon, Ga., exploded on July 21st, doing considerable damage. Fortunately no one was standing near enough to get hurt. A large force of men went to work on the boiler at once, and the damage was repaired in about ten days.

Threshing Engine (126). The boiler of Hayes & Lindsey's steam thresher exploded on July 22d, on James Durbin's farm, in Edmonson county, Ky., near Litchfield. John Durbin, Will Basham, and John Massy were killed, and Peter Pierce, Kit Yates, Job Blanton, Oliver Phelps, and Thomas Lindsay, dangerously hurt.

Locomotive (127). On July 22d, the boiler of engine No. 12 exploded in Plattsmouth, Neb., in the roundhouse of the B. & M. railroad. Charles Hasemeyer and John Hardroba were killed, and Frank Mauer was perhaps fatally injured. E. B. Thrall and Charles Miller were also injured. The jury at the coroner's inquest decided that the explosion was due, primarily, to a defective steam gauge, the safety-value having been adjusted so as to agree with the erroneous reading of the gauge.

Saw-mill (128). Mr. A. Lee owns the steam saw-mill situated about two miles east of Nineveh, N. Y. On July 23d, the boiler of his mill exploded, killing Fred Wheeler, James Shaw, and Thomas Markham, and wrecking the mill and machinery.

Steam Yacht (129). At Parker, Pa., on July 24th, a young man named Karns invited some of his friends to take the first sail in his new yacht. When out in deep water, the boiler exploded, throwing the party out. All escaped by swimming to the shore except George Stein, who was drowned.

Furniture Factory (130). On July 25th, the boiler in the Manly Furniture Company's factory, Warsaw, Ind., blew up, greatly damaging the building and severely injuring the fireman, John Hoag. Noticing that the steam was running higher than usual and necessary, and that the water was rather low, Hoag attempted to put on the pump and run down the steam. Before he could get the pump to work, the explosion came, and with it the flying bricks, timbers, and fragments of the boiler. Hoag received a long, ugly gash on the top of the head, and another severe cut in the back, with several minor bruises, all more or less painful. He was blown fifty feet away and landed in the center of a grass-plat insensible. The engine room was demolished, and the main building was damaged. The loss is estimated at $4,000.

LOCOMOTIVE (131). The crown sheet of switch engine No. 40, on the New York, New Haven & Hartford railroad, blew out at Stamford, Conn., on July 25th, and the engineer and fireman were horribly scalded.

SOAP WORKS (132). On July 26th, there was a boiler explosion at Babbitt's Soap Works, 67 to 74 Washington street, New York.

WAREHOUSE (133). A boiler exploded in the rear of the Hill City Warehouse, Vicksburg, Miss., on July 27th. Engineer Albert Spieler and Fireman Albert Fisher were killed. The boiler, a small upright, fell into the house of Mr. Marx Lorrenburg and brought up in the center of his breakfast table, after plunging through the roof, floor, and ceiling, cutting a hole about eight feet square. His family had just left the table, being attracted to a window. Mr. H. Kestenbaum, a boarder, was slightly hurt, however, by falling plaster from the ceiling. The cause of the explosion is unknown.

THRESHER (134). On July 27th, as the steam thresher of Sam Grigsby was at work, threshing the wheat on W. F. Phipps' farm at Stony Point, near Rogersville, Tenn., the boiler exploded and instantly killed a colored boy, and wounded several others. Mr. Phipps was scalded. The rick of wheat caught fire, and about 150 bushels burned.

THRESHER (135). At Sulphur Springs, near Newcastle, Ind., the boiler of the threshing engine of White & Co. bursted on July 28th, tearing the engine all to pieces, but fortunately injuring nobody.

SASH FACTORY (136). On July 28th, a boiler exploded in a sash and door factory in Cummings, near Toledo, Ohio, killing the fireman, Charles Moore, and seriously scalding David Sigler, Frank Miller, John Inman, and William Enz. Had the explosion occurred half an hour later, it would have been much more disastrous.

STEAM LAUNCH (137). On May 20th the swift steam launch *Aquilla* burst two tubes of her boiler while running on Puget Sound. The engineer and a deck hand were badly scalded. This boat was formerly owned by W. R. Hearst of San Francisco, and was built by Herreshoff.

BARREL FACTORY (138). A boiler exploded on June 13th in the barrel factory and machine shop of E. J. Rubottom, Felton, Cal. Two men, William Aban and J. Plumber, were badly scalded, as was also Joseph Fevere, a boy of 12.

[We received notice of this explosion and of the preceding one, too late to include them in their proper places.]

IN connection with the experiments on the artificial production of rain, which the Weather Bureau is carrying on, the Chicago *Inter-Ocean* says: "During the war it was a matter of common observation that heavy firing, whether of musketry or cannon, was invariably followed by rain. Professor Everett thought that great battles or great fires produced rain, but whether the rainfall was due to the flame or the concussion he was unable to determine. Rain often follows or accompanies volcanic eruptions, and it has been said that the annual precipitation is invariably increased in years that are remarkable for seismic disturbances." It seems likely that the experiments may be successful when the air contains an abundance of moisture, but it is doubtful if any artificial means can produce rain under other circumstances.

The Elastic Limit.

When engineers first began to test the materials they used in their structures, it was very quickly recognized that if a specimen was loaded beyond a certain point, it did not recover its original dimensions on removing the load, but took a permanent set. The limiting stress on straining below which no permanent set could be detected on removing the load, was called the elastic limit. Since under these conditions a bar appeared to recover completely its original form and dimensions on removing the load, it appeared obvious to the first experimenters that it had not been injured in any way by the load, and hence the working load might be deduced from the elastic limit by using a small factor of safety.

Experience showed, however, that in many cases a bar would not carry safely a stress anywhere near the elastic limit of the material as determined by these experiments, and the whole theory of any connection between the elastic limit of a bar and its working load became almost entirely discredited, and engineers employed the ultimate strength only in deducing the safe working load to which their structures might be subjected. Still, experience gradually accumulated, and it was observed that a higher factor of safety was required for a live load than for a dead one. This was at first attributed to the effect of impact, and to a certain extent this was, no doubt, true; since if a moving body strikes a structure, the work stored up in the body must be taken up by the elastic deformation of the structure, which will be correspondingly greater than if the load was gently laid on it. In 1871, however, Wöhler published the results of a number of experiments on bars of iron and steel subjected to live loads. In these experiments the stresses were put on and removed from the specimens without impact, but it was, nevertheless, found that the breaking stress of the materials was in every case much below the statical breaking load. Thus, a bar of Krupp's axle steel having a tenacity of 49 tons per square inch broke with a stress of 28.6 tons per square inch, when the load was completely removed and replaced without impact 170,000 times. These experiments were made on a large number of different brands of iron and steel, and the results were absolutely concordant in showing that a bar would break with an alternating stress of only, say, one-third the statical breaking strength of the material, if the repetitions of stress were sufficiently numerous. At the same time, however, it appeared from the general trend of the experiments that a bar would stand an indefinite number of alternations of stress, provided the stress was kept below the limit.

These experiments, while they showed that the impact was insufficient to account for the peculiarly detrimental action of a live load, and that the statical breaking strength was not sufficient in itself to properly proportion a structure, did nothing toward rehabilitating the elastic limit as a measure of the safe working load of a material. For this it now appears there were several reasons. We believe it was Sir Frederick Bramwell who professed to be unable to say what a horse-power was, because, first, there was the true horse-power of about 22,000 foot-pounds per minute, next there was Watt's horse-power of 33,000 foot-pounds per minute, and finally there was nominal horse-power, which was anything the engine-builder liked to make it. A remark of the same nature might be made with reference to the elastic limit. There is first the maker's elastic limit, which is the yield point of the material as it comes from the rolls; next there is the real primitive elastic limit of the material, which corresponds to the point at which stress ceases to be sensibly proportional to strain, the bar being tested after being brought to a state of ease; finally, there is the elastic limit of the bar after it has been loaded in various ways, which may be anything the experimenter chooses to make it, up to nearly the breaking point.

It is to Professor Bauschinger of the Munich Technological Laboratory that we owe the proof of the fact that the elastic limit has nothing whatever to do with the breaking down point with which it is so commonly considered as identical. Professor Bauschinger defines the elastic limit as the point at which stress ceases to be sensibly proportional to strain, the latter being measured with a mirror apparatus reading to $\frac{1}{5000}$th of a millimetre, or about $\frac{1}{100000}$ in. This limit is always below the yield point and may on occasion be zero. On loading a bar above the yield point, this point rises with the stress, and the rise continues for weeks, months, and possibly for years if the bar is left at rest under its load. On the other hand, when a bar is loaded beyond its true elastic limit, but below its yield point, this limit rises, but reaches a maximum as the yield point is approached and then falls rapidly, reaching even to zero. On leaving the bar at rest under a stress exceeding that of its primitive breaking down point, the elastic limit begins to rise again and may, if left a sufficient time, rise to a point much exceeding its previous value.

This property of the elastic limit of changing with the history of a bar has done more to discredit it than anything else, nevertheless it now seems as if it, owing to this very property, were once more to take its former place in the estimation of engineers, and this time with fixity of tenure. It had long been known that the limit of elasticity might be raised, as we have said, to almost any point within the breaking load of a bar. Thus, in some experiments by Professor Styffe, the elastic limit of a puddled steel bar was raised 16,000 lbs. by subjecting the bar to a load exceeding its primitive elastic limit, and similar cases could be multiplied indefinitely. Most experimenters, however, had overlooked the importance of the fact that a bar has two limits of elasticity, one for tension and one for compression, and it was reserved for Professor Bauschinger to determine whether the raising of the elastic limit in tension had any effect on the limit for compression. Taking a number of bars as received from the factory, these bars were first loaded in tension until stress ceased to be sensibly proportional to strain. The load was then removed and the bar tested in compression until the elastic limit in this direction had been exceeded. This process raises the elastic limit in compression, as would be found on testing the bar in compression a second time. In place of this, however, it was now again tested in tension, when it was found that the artificial raising of the limit in compression had lowered that in tension below its previous value. By repeating the process of alternately testing in tension and compression, the two limits took up points at equal distances from the line of no load, both in tension and compression. These limits Bauschinger calls natural elastic limits of the bar, which for wrought-iron correspond to a stress of about 8½ tons per square inch, but this is practically the limiting load to which a bar of the same material can be strained alternately in tension and compression, without breaking when the loading is repeated sufficiently often, as determined by Wöhler's method, and it is now possible to explain why the bars break at such unexpectedly low loads when thus subjected to alternating stresses. As received from the rolls the elastic limit of the bar in tension is above the natural elastic limit of the bar as defined by Bauschinger, having been artificially raised by the great deformations to which it has been subjected in the process of manufacture. Hence, when subjected to alternating stresses, the limit in tension is immediately lowered, while that in compression is raised until they both correspond to equal loads. Hence, in Wöhler's experiments, in which the bars broke at loads nominally below the elastic limits of the material, there is every reason for concluding that the loads were really greater than true elastic limits of the material. This is confirmed by tests on the connecting-rods of engines, which of course work under alternating stresses of equal intensity. Careful experiments on old rods show that the elastic limit in compression is the same as that in tension, and that both are far below the tension elastic limit of the material as received from the rolls. It thus appears that those engineers who have discarded the idea of the elastic limit as a measure of the working strength of a bar, and have proportioned their structures from the results obtained by Wöhler, have really, in spite of themselves, been working on the very assumption they professed to discard. "Thus the whirligig of time brings in its revenges."

Hard steel is so little used, comparatively speaking, in the work of an engineer, that most people are, on first becoming acquainted with the facts, greatly surprised at the high stresses under which such steel is worked in springs. Mr. Hartnell has pointed out that the safe working load of such springs is often as much as 60,000 lbs. to 70,000 lbs. per square inch, and in some experiments on a volute buffer spring Mr. A. E. Young has found that stresses of 59 tons per square inch were safely carried. Specimens of the same steel in an unhardened condition showed an elastic limit of 43 tons per square inch in tension, with a breaking stress of 68.77 tons per square inch. A similar bar, after hardening, broke at a stress of 67.73 tons per square inch with an elastic limit of 67.33 tons, or very nearly equal to the breaking load of the bar. No experiments were made on the compression elastic limits; but if, as is probable, the effect of the hardening also raised the limit in compression, it is easy to see why steel is hardened and tempered before being used for springs, although the modulus of elasticity of the metal is unchanged. The elastic limits being raised by the hardening, greater working loads can, on Professor Bauschinger's theory, be carried, and experience bears this out.

The opinion has at various times been emitted that straining a metal beyond its elastic limit injures it, but this appears to be untrue. It is not the mere straining of a metal beyond one elastic limit that injures it, but the straining, many times repeated, beyond its two elastic limits. Sir Benjamin Baker has shown that in bending a shell plate for a boiler the metal is of necessity strained beyond its elastic limit, so that stresses of as much as 7 tons to 15 tons per square inch may obtain in it, as it comes from the rolls, and unless the plate is annealed, these stresses will still exist after it has been built into the boiler. In such a case, however, when exposed to the additional stress due to the pressure inside the boiler, the over-strained portions of the plate will relieve themselves by stretching and taking a permanent set, so that probably after a year's working very little difference could be detected in the stresses in a plate built into the boiler as it came from the bending rolls, and in one which had been annealed, before riveting into place, and the first, in spite of its having been strained beyond its elastic limits, and not subsequently annealed, would be as strong as the other.

As another instance of the ideas very commonly prevailing, we may note that objection has been raised to the theory of wire gun construction in that it depends upon the assumption that the wire is not strained beyond its elastic limit, and that, as in the very process of being wound in place the wire must of necessity take a permanent set, the foundations of the theory are unstable, and that hence all the algebraic formulæ for the tension of the wire are useless. This objection does not seem to us well founded. No doubt, if the wire is wound on to the gun from another roller, it is permanently deformed in the process, and owing to its plasticity, stresses of the nature of those due to bending will exist in it after being wound into place, and thus the ring tension will not be uniformly distributed over the section of the wire. As this wire is thin, however, these stresses should not be high, and as, moreover, the overstrained portions will be able to relieve themselves by a plastic yielding, if necessary, thus transferring part of their load to the neighboring understrained fibres, while the mean tension remains the same, there is no reason for supposing that this unequal distribution of stress over the section of the wire seriously affects the application of the formulas, or the validity of the theory on which these formulas are based. The conditions, indeed, are much the same as in the case of the boiler shell plate discussed above, and as experience proves that such boilers can be constructed successfully without annealing these plates, our conclusions as to the wire gun may be said to be confirmed by experience. The real objection to wire guns appears to be the want of longitudinal stiffness resulting in drooping of the muzzle, but this is a question not entering into the scope of this article.—*Engineering, Aug. 7, 1891.*

The Locomotive.

HARTFORD, SEPTEMBER 15, 1891.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

THE LOCOMOTIVE *can be obtained free by calling at any of the company's agencies.*

Subscription price 50 cents per year when mailed from this office.

Bound volumes one dollar each. (Any volume can be supplied.)

Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

MESSRS. JOHN WILEY & SONS, of 53 East Tenth Street, New York, send us the first volume of Dr. Robert H. Thurston's *Manual of the Steam Engine*, which we have examined with much pleasure. "In the construction of this work," says the preface, "it has been assumed that the reader is familiar with the higher mathematics and the principles of thermal physics, and generally well-read in those subjects which constitute the essential scientific basis of the professional training of the engineer. This assumption, which would have been unjustifiable a generation ago, is to-day perfectly reasonable. The profession of engineering has become one of the learned professions in a single generation, a consequence of the rapid development of the system of technical education now forming an essential and, often, the most extensive department of modern education in all civilized countries. The book is intended especially for the use of educated, practising engineers and of students, under-graduate and graduate." The present volume discusses the history of the steam-engine, the structure of modern engines, the philosophy of the steam-engine, the thermo-dynamics of gases and vapors, the theory of the steam-engine, compounding, jacketing, and superheating, and the general question of efficiency. Useful tables are given in an appendix. In the second volume it is proposed to consider steam-engine design, valves and valve motions, governors, flywheels, and the inertia of moving parts, construction, erection, care, management, engine and boiler trials, specifications and contracts, costs and estimates.

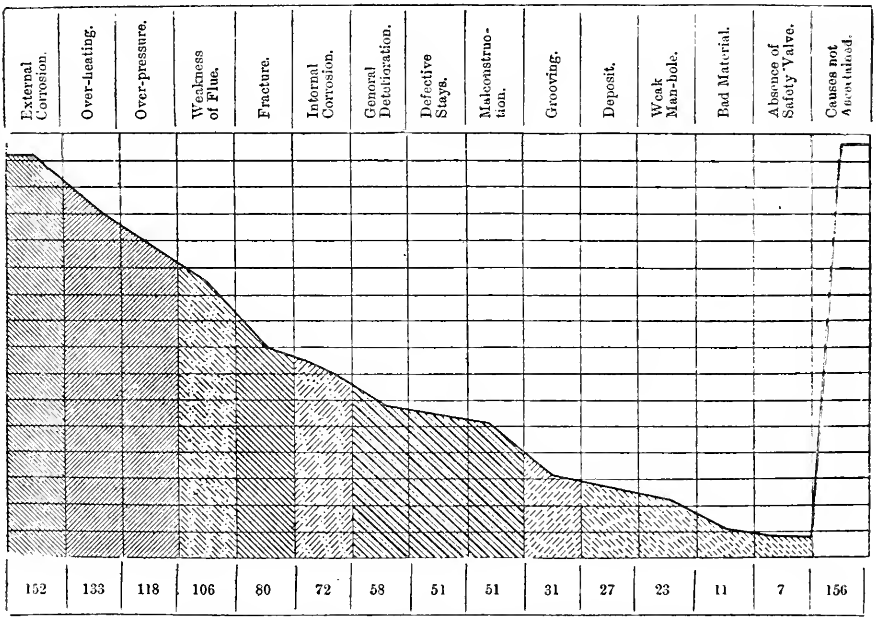
The book contains some 870 pages, and Dr. Thurston's name is sufficient to indicate its character. The price of the volume is $7.50.

PROF. A. E. FOOTE read a remarkable paper before the geological section of the American Association for the Advancement of Science at its recent meeting at Washington. In June of the present year Prof. Foote explored Crater Mountain, 185 miles north of Tucson, Arizona, and found some wonderful meteorites there. The hardness of one of the specimens attracted particular attention, and careful examination revealed small black diamonds in some of the cavities. A white diamond about one-fiftieth of an inch in diameter was also found.

Until 1887 diamonds were not known to exist in meteorites, and, so far as we are aware, the present find is the most extensive one yet made. It need hardly be said that the discovery is of immense scientific importance. Apart from the purely mineralogical interest aroused by finding diamonds in such an unexpected place, it affords some information concerning the celestial spaces through which the earth moves. Scientists tell us that there is some benzene vapor in the region that the solar system is now passing through, and Roscoe is inclined to think that the diamonds found in South Africa may have resulted from the decomposition of a substance somewhat resembling benzene which he found in the soil at the Kimberly mines. It is possible that there is some sort of connection between these two facts, though it is not easy to guess what the relation can be. The indications on the earth are, that diamonds are formed from organic substances. Are we to infer, then, that these meteorites came from distant places where life has existed at some time or other? So little is really known about the formation of diamonds that it would be absurd to assert any such thing as this as anything more than a speculation, for the conditions to which meteorites are exposed in space are so different from those that we can produce in our laboratories that there is no knowing what inimitable results may be worked out in these celestial visitors of ours before they reach us.

The Causes of Boiler Explosions.

The accompanying diagram shows graphically the causes of 1,079 boiler explosions, and is based upon an analysis of available reports of boiler explosions over a series of years. It was prepared by Mr. B. H. Thwaite for his lecture on steam generators, delivered in England a short time ago, before the Yorkshire College Textile Society; and we reproduce it from *Industries*.



Number of Explosions from the Causes Enumerated Above.

We wish to correct a statement made in the August issue of The Locomotive, under Explosion No. 99. The San Diego *Union* of June 6th, from which our account was taken, says the boilers were tested by steam pressure; but we learn that this was not the fact. They were tested hydrostatically, and the cast iron manhole frame gave way, tearing the sheets along the side nearly the whole length of the boiler. We are glad to make this correction, because the original account, through no fault of ours, reflected unjustly upon the government inspector of that district.

The Trans-Atlantic Record again Broken.

Our August issue, announcing the wonderful performance of the White Star liner *Majestic*, was hardly out when her sister ship, the *Teutonic*, whose best previous record was disputed, completed the voyage in 5 days, 16 hours, and 31 minutes, arriving at Sandy Hook on Aug. 19th. This is 1 hour and 37 minutes quicker than the *Majestic's* time.

The *Teutonic* also made the longest run yet made in a single day, 517 miles, as will appear by the following table of daily runs:

Days.	Teutonic.	Majestic.	City of Paris.
First, ...	460	470	432
Second, ...	496	501	493
Third, ...	505	497	502
Fourth, ...	510	501	506
Fifth, ...	517	491	509
Sixth, ...	290	317	346
Total, ...	2,778	2,777	2,788

The average speed for the voyage was 20.349 knots per hour. At times her engines developed 19,900 horse power, and her average coal consumption, it is said, was about 310 tons a day.

An Amazing Collection of Prehistoric Animals.

In a recent issue the New York *Sun* describes a remarkable collection of fossil remains that is about to be transported from New Haven to Washington. "Beasts with backbones full of hot air, and separate brains to wag their tails with," remarks our contemporary. The account is so interesting that we reproduce it in full:

"In this wonderful parade will be gigantic reptiles as big as good-sized houses, some of them 100 feet in length, flying dragons with a 25-foot spread of wings, huge birds with teeth, mammals two or three times as big as elephants, sharks as large as the hugest whales, other fishes clad in mighty plates of armor, and countless specimens more of equal strangeness and enormous dimensions, such as actually inhabited the world before man arrived in it. For nine years past the Government has been digging up and putting together the skeletons of these strange creatures, and now the vast collection, at present stored in New Haven, Conn., is preparing for shipment by rail to the National Museum. The whole of it would occupy fully one-half of that institution's building here, and so only a portion is to be forwarded immediately, the rest to follow as soon as quarters have been established by Congress for its accommodation.

"The business of digging for these tremendous fossils is carried on pretty much like any other mining. In various parts of the West there are great deposits of them, into which the scientific enthusiasts eagerly delve for relics of epochs thousands of centuries old. One of their chosen hunting grounds is the region between the Rockies and the Wasatch Mountains. Ages ago the upheaval of these hills by geologic action cut off the portion of what had been sea between these ranges from the ocean, and the water thus shut away formed many big lakes. A typical one of this sort existed in Wyoming, and around it the mighty antediluvian mammals gathered in herds to crop the succulent and luxuriant vegetation of what was then a tropical climate in that region. They died natural deaths or became mired in the mud when they went to drink, and the sediment slowly deposited in the water covered up their bones and preserved them from decay.

This sediment reached a mile in thickness, holding between its layers these ancient skeletons, distributed like currants through a cake. At length the water draining off, left the land dry, and, in the case of the Wyoming lake referred to, subsequent floods washed away much of the sediment previously deposited, leaving what are now called "bad lands"—picturesque with cliffs, peaks, and columns, carved out in fantastic shapes and of variegated coloring.

"Through such a region as this the scientific explorer travels with his eyes as wide open for fossils as the gold hunter keeps his for the shining metal. If from the face of some rocky cliff he chances to see a bone project, exposed by the action of water that has cut away the hillside, he sets a party of men to quarrying with drill, blast, and pickaxe, until whatever is there in the way of remains has been taken out. Possibly some great deposit of prehistoric monsters may be struck in this way, in which case the find is kept as secret as possible, being regarded by the discoverer as his private mine. If he gave it away, rival palæontologists would rush to the spot and dig out all the animals for their own study and glory. Prof. O. C. Marsh, who directed the gathering of the Government collection referred to, has such mines of his own all over the West, from which he can draw to order the most astonishing variety of gigantic creatures. He made the remark the other day that there was one small valley he knew of, where relics of the ancient mosasaurus were so plentiful that, passing through it recently, he noticed skeletons of six of those mighty swimming lizards, each eighty feet in length, in sight at one time.

"Usually these amazing fossils are found imbedded in solid rock. After they have been roughly quarried out, the sandstone or other matrix enclosing them is carefully chiseled away from the bones. The latter receive a coat of glue to keep out the decomposing air, and any that are broken or splintered are bound up with twine, after which they are packed for shipment. When one of these beasts of antiquity died, its carcass being covered up with sediment that afterward became stone, the skeleton was apt to be preserved entire and with its parts in position, all ready for mounting in a museum. A new reptile was found in Wyoming the other day in such a complete state, which has been named brontosaurus. It was 60 feet long, stood 15 feet high when alive, and weighed twenty tons. Cast in the rock from which it was taken was a perfect mould of one of its eyeballs, with which it looked upon the world three millions of years ago. It had a very small head, a long and flexible neck, a short body, and a huge tail. In the same neighborhood also has been discovered recently another reptilian monster called the triceratops, which had an enormous bony frill around the back of its neck. This surprising development, measuring six feet across, was intended for the attachment of great muscles that were necessary for holding up the huge head. The animal, though tremendously massive, was only thirty feet long; but it was covered with plates of armor and had a sharp and horny beak, not to mention a horn on its nose and another on its forehead, the latter 2½ feet in length.

"In Colorado have been found great deposits of the bones of titanosaurs, the biggest land animals that ever existed. They grew to be 65 feet long and stood 40 feet high when erect upon their hind legs. Instead of browsing, as did the brontosaur and triceratops, upon the luxuriant aquatic vegetation around the lake borders, they fed upon the foliage of trees on the mountain sides. Likewise did the iguanodon, several times as heavy as an elephant, which had a nipping beak like a turtle's and also walked erect, using its huge tail for a support and towering to the height of 40 or 50 feet.

"In the mesozoic epoch, or 'Age of Reptiles,' when those creatures lived, these and other similar herbivorous animals were the biggest of the beasts. One of them, the atlantosaur, was 100 feet long, its thigh bones, many of which have been found, measuring eight feet in length and twenty-five inches through. They had various methods of pursuing existence. Some went on all fours and had backbones that were mere shells filled with warm air from their lungs, which served them as floats while they walked in the sea shallows in water deep enough to cover their backs, extending their long necks to crop the vegetation alongshore. Of this sort was the camerasaurus, eighty feet in length. Others had enormously long hind legs, on which they were able to wade out far into the ocean after seaweeds, and were provided with not fewer than 2,000 teeth for grinding their food. Such was the mighty kangaroo-like hydrosaurus. Yet other species dwelt on land, like the triceratops, and these were provided usually with armor and horns for defense.

"It would seem as if such monsters as are described need have feared no living foes, but in fact they were a common prey to great numbers of frightful carnivorous reptiles, smaller in size, but of tremendous activity and fierceness, which fed upon these unwieldy, vegetable-eating giants. Most terrific of all, perhaps, was the incredibly ferocious lælaps, which was forty feet long, stood twenty-five feet high on its hind legs, and was built like a kangaroo. It was the most astonishing jumper that ever existed, with teeth for cutting, and sharp claws on the front feet, evidently designed for tearing out the eyes of victims or adversaries. Hardly less formidable, and equally large, was the stagosaur, which was sheathed in armor-plates from two to three feet in width, and employed as a weapon of offense its powerful tail, armed near the end on both sides with sharp spikes two feet long. This animal walked erect also, and one of its peculiarities was a great enlargement of the spinal cord at the lower end of the back. In fact, this expansion of brain material, intended to provide for the wagging of the mighty spiked tail, was ten times as big as the brain in the skull itself. Equally large and dangerous were the megalosaur and the dinosaur, their jaws armed with huge sabre-like teeth, which went about on their hind legs looking for something to devour. Against such fearful foes what chance had the peaceful cetiosaurus and elasmosaurus, dwelling in marshes and shallows, with the bulk of six or eight elephants? Nevertheless, some of the herbivorous land reptiles referred to, like the gigantic horned and armored agathumas, could make a good fight with the carnivores, and were so well able to defend themselves that they lived and multiplied in the same regions with the latter. But most of these vegetable feeders had no other means of defense than kicking, which they could do with some effectiveness with hind legs fifteen feet or so in length.

"Specimens of all these are included in the collection that is to be brought here for permanent exhibition. Of course, they represent but a few of the countless species of giant beasts that roamed over the earth in droves during this vanished epoch. That was the age when reptiles ran creation. They walked upon land, swam the seas, flew through the air, climbed trees, and did everything that mammals do nowadays. There were bird reptiles and reptilian birds. Some had wings for flying with a spread of twenty-five feet — veritable dragons, in fact. Others, forty feet in length, had paddles for swimming like a whale's. These latter lived in the seas, though occasionally they came on shore. It is known from their petrified droppings, which are plentifully found to-day, that they lived upon fish. One species dived to great depths in the ocean, and was most rapacious and predatory. It had enormous eyes to see with in deep water, its head resembling an alligator's. Another kind with a very long neck inhabited the shoals and preyed upon the fishes of the shallows. The first serpents, too, belonged in the sea and grew to be forty feet long. They had no poison, but were constrictors, like the boa. There were many kinds of crocodiles fifty feet from snout to tail, whereas the biggest ones now are not more than fifteen feet. During the same period lived the birds with teeth, which were only discovered a few years ago. Biggest of these was the hesperornis, which stood six feet high, and had only rudimentary wings. It did not fly, therefore, but was simply a swimmer and diver, subsisting on fish. The ichthyornis was somewhat similar in appearance and habits, but not much larger than a pigeon. It is supposed that these strange water fowl were wiped out by the giant swimming lizards, eighty feet long, and clad in bony armor plates, which resembled the modern conception of the sea serpent. The turtles should not be forgotten, which attained a length of twenty feet, and measured seven feet in height.

"It is not only the age of reptiles, however, that is represented by the unparalleled collection described. Before that came the epoch of fishes, when they ran the world and had all creation pretty much to themselves. Of this era likewise the Government has gathered together a vast quantity of fossil relics. The face of the earth did not look then at all as it appears now. Most of what are now called the continents had not been upheaved above the ocean; nearly everywhere was sea, with comparatively small land masses elevated out of it. The atmosphere was hot, moist, and loaded with carbonic acid, so as to be unbreathable. In the waters swam enormous armored fish, such as the dinichthys, which was fifteen feet long and had such tremendous jaws and teeth that it could have bitten a man in two as easily as you would a radish. Later on came sharks of the fiercest type, which must have been as much as seventy feet in length at least. The biggest tooth of a maneater of to-day is about an inch long, while the teeth of these ancient sharks, found in enormous numbers, measure more than six inches. That was the golden age of the scaly tribe.

"The giant reptiles that appeared on the scene in the subsequent epoch were remarkable for the smallness of their brain cavities. In some of them the brain was so small that it could have passed without injury through all the vertebræ of the spinal column down as far as the beginning of the tail. All of them were wiped out of existence by the great cataclysm which upheaved the Rocky Mountains, the Alps, and the Himalayas, and brought to a close the mesozoic epoch. Then came the age of mammals, at the end of which we are now, man being the last arrival on the scene.

"The age of monsters pretty nearly has passed away, only a few remaining, like the elephant and the whale. Small animals with plenty of sense will always survive stupid giants in the long run, because they require less food and know better how to avoid danger. Observe in illustration how the doom of extinction has fallen upon the gigantic mammals which roamed over the earth by myriads only so short a time ago, comparatively speaking, as the beginning of the present era, called the cenozoic. There was the dinoceras, which lived in herds about the lakes, as the deposits show, big as an elephant, but in appearance somewhere between the rhinoceros and the hippopotamus, with three pairs of horns on its head and huge sabre-like tusks that fitted into sheaths in the lower jaw. More imposing yet was the tinoceras, somewhat similar of aspect and sixteen feet long. Not less impressive was the megatherium or giant sloth, as large as two elephants, and which attained a measurement of eighteen feet, and procured the leaves on which it fed by seating itself upon its mighty haunches and uprooting great trees. Of the dinotherium no complete skeleton has been discovered, but it was, doubtless, the biggest land mammal that ever lived. A full-grown skull of this earliest of proboscidians, which had long tusks as well as a trunk, measures five feet from the point of the lower teeth to the top of the head. The brontops, of elephantine size, had a head like a rhinoceros, with huge horns. Quite as remarkable was the sivathorium, a beast like an antelope, but big as an elephant, with two conical horns on the front of its head and two immense spreading ones behind. Among birds were waders ten feet in height, such as the dinornis and gastornis. Contemporary with them were the mammoth and the mastodon, the woolly rhinoceros, armadillos nine feet in length, and the sabre-toothed tiger, larger than the greatest lion of to-day. All that is left of these wonders of animal life is found in deposits such as those of the Western lake beds. For years the Government has been engaged in excavating their bones, which are now to make part of what is to be the greatest zoölogical show on earth."

The Locomotive.

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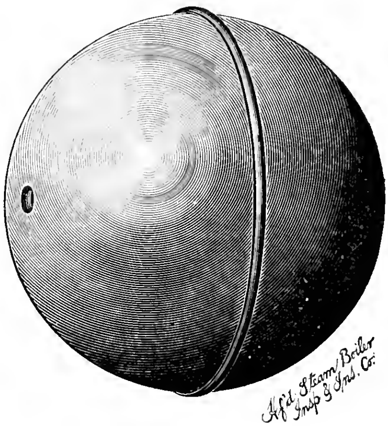
On Hollow Copper Balls.

Hollow copper balls are used a good deal in engineering practice, especially as floats in boilers or tanks, to control feed and discharge valves, and regulate the water level. They are often exposed to a considerable external pressure, so that it is important to have a rule for calculating the pressure at which they will collapse.

The cut illustrates the usual form of these floats. They are spun up in halves from sheet copper, and a rib is formed on one half. Into this rib the other half fits, and the two are then soldered or brazed together. In order to facilitate the brazing, a hole is left on one side of the ball, as shown in the cut, to allow air to pass freely in or out ; and this hole is made use of afterwards, to secure the float to its stem. The original



A COPPER FLOAT.

thickness of the metal may be anything up to about $\frac{1}{16}$ of an inch, if the spinning is done on a hand lathe, though thicker metal may be used when special machinery is provided for forming it. In the process of spinning, the metal is thinned down in places by stretching; but the thinnest place is neither at the equator of the ball (*i. e.* along the rib) nor at the poles. The thinnest points lie along two circles, passing around the ball parallel to the rib, one on each side of it, from a third to a half of the way to the poles. Along these lines the thickness may be 10, 15, or 20 per cent. less than elsewhere, the reduction depending somewhat on the skill of the workman.

The quality of the metal is much improved by the process of spinning, and it is rendered harder, tougher, and stronger; but along the rib, where the brazing is done, the heat softens it up again and brings that part of the ball which lies near the rib back to its original condition. This is, to some extent, counteracted by the stiffening action of the rib itself, so that, taking everything into consideration, we cannot be greatly in error by regarding the ball as a sphere of uniform strength throughout.

If the pressure is on the *inside* of the ball, it tends to *remove* any slight accidental departure from the spherical form: an egg-shaped ball, for instance, would be drawn in at the ends and bulged out around the middle by a pressure inside of it. But when the pressure acts on the *outside* of the ball, its tendency is just the opposite. Accidental variations of the surface from perfect roundness are increased by the pressure, and may be so much increased that the ball becomes so much deformed as to collapse, even when the pressure is far below that which would cause the metal to fail by direct crushing. In fact, it seems evident that a perfectly round ball, everywhere of precisely the same strength and thickness, could not collapse under any pressure, however great. The diameter of the ball would grow smaller and smaller with increasing pressure, and its thickness would continually increase until there was nothing left but a small, solid sphere of metal, with perhaps a single round bubble of highly compressed air at the center. Of course, this condition is unattainable in practice, but we speak of it in order to make it plain that when copper floats do fail, it is because they were not originally perfectly round, or perfectly uniform in thickness or in material.

It is desirable, therefore, that we should have some experimental tests of balls of different diameters and thicknesses, so that we might learn what effect such irregularities may be expected to have in the balls that are met with in the trade. There seems to be an entire absence of such data, however; or, if tests have been made, they are probably in use by manufacturers who do not care to give others the benefit of them.

Since it appears hopeless to find any satisfactory rule from existing experimental data, and since the writers on mechanics and strength of materials do not offer us anything satisfactory in the way of a theoretical rule, we must be contented with a makeshift substitute. This may be had by finding the pressure that would begin to crush the metal of the ball, if it were homogeneous and uniformly round and thick, and then allowing a sufficient factor of safety to probably cover the collapsing tendency.

Consider a section of the ball through the center. The pressure forcing the two halves of the ball together is equal to the area of the section multiplied by the pressure per square inch on the surface of the ball. That is, the total pressure forcing the halves of the ball together is .7854 × *square of diameter* × *pressure per sq. in. on the ball.* This must be resisted by the total compressive strain in the metal of the cross-section, which is equal to the compressive strain per square inch, multiplied by the number of square inches of the section of metal. The area of the metal in a section passing through the center of the ball is equal to the circumference of the ball, multiplied by the thickness of the metal — that is, the area of metal is equal to 3.1416 × *diameter* × *thickness;* and the total compression on the ring of metal is equal to 3.1416 × *diameter* × *thickness* × *compression per sq. in.* This must be equal to the crushing force exerted by the pressure on the outside of the ball, so that .7854 × *square of diameter* × *pressure per. sq. in. on the ball* = 3.1416 × *diameter* × *thickness* × *compression of metal per sq. in.* It follows from this that the

$$\left\{\begin{array}{l}\textit{Compression per sq. in. in the}\\ \textit{metal of the ball}\end{array}\right\} = \tfrac{1}{4}.\frac{\textit{diameter} \times \textit{pressure}}{\textit{thickness}}$$

If we take the ultimate crushing strength of sheet copper as 32,000 pounds per square inch, the foregoing formula gives

$$32{,}000 = \tfrac{1}{4}.\frac{\textit{diameter} \times \textit{pressure}}{\textit{thickness}}$$

The thickness is what we usually wish to find, as the diameter and pressure are usually determined by other considerations; so by turning our formula around we find

$$Thickness = \frac{diameter \times pressure}{4 \times 32,000}$$

This gives the thickness of a shell that the given pressure will just crush; so that, if we wish to have the ball work under this pressure, we must multiply the result of the foregoing formula by an appropriate factor of safety, which must be great enough to take account not only of the uncertainty of the material, but also of the liability of the ball to collapse instead of crush. It is not easy to say what this factor ought to be, but experience indicates that if the ball is well made a factor of safety of 8 ought to be sufficient. Hence we have, as the thickness of a ball which is to work under a given pressure,

$$Thickness = \frac{diameter \times pressure}{16,000}$$

As a numerical example, let us calculate the thickness of a float 5 inches in diameter, to stand a pressure of 200 pounds to the square inch. We have $5 \times 200 = 1,000$, and $1,000 \div 16,000 = \frac{1}{16}$. Hence the ball should be made of sheet copper, $\frac{1}{16}$ of an inch thick.

There is another way in which the collapsing pressure of spheres may be approximated, though we doubt if it is to be preferred to the foregoing method. Fairbairn's rule for finding the collapsing pressure of a flue, is as follows: Multiply the square of the thickness by the constant 9,672,000, and divide the product by the diameter and by the length, all dimensions being in inches. The result is the collapsing pressure in pounds to the square inch. (Fairbairn used the 2.19 power of the thickness, but it is now customary to use only the second power, omitting the decimal.) Now, the bursting pressure of a sphere is just twice the bursting pressure of a tube of the same diameter and thickness, the difference being due to the fact that the sphere has curvature in *two* directions instead of only *one*, as in the tube. It may be fair, therefore, to assume that for the same reason the collapsing pressure of a sphere is about twice as great as that of a tube of the same diameter. If this may be admitted, we may apply Fairbairn's rule to spheres by calling the length of the sphere equal to *half* its diameter. In applying it to copper spheres, a change must be made in the constant of the formula, of course, on account of the difference in the material. It is not easy to determine what this constant should be, except by experiment, but from the table in Rankine's *Applied Mechanics*, page 633, we take 6,200,000 as the nearest available number. The rule for the collapsing pressure of a copper sphere would then be: Multiply the square of the thickness by 6,200,000, and divide by half the square of the diameter.

Allowing a factor of safety of 8, as before, this rule amounts to the following: To find the safe working pressure on a copper sphere, multiply 1,550,000 by the square of the thickness, and divide by the square of the diameter.

With the same factor of safety the foregoing rule may be turned around so as to read this way:

RULE: *To find the thickness that a hollow copper ball should have, multiply the square root of the working pressure by the diameter of the ball, and divide by 1,240.* (This rule agrees exactly with the one already given when the pressure is 166 lbs. At other pressures the agreement is not exact.)

As a numerical example of this rule, let us calculate the thickness a five-inch ball should have, to stand a working pressure of 200 pounds to the square inch. We have already solved this example by the other method, and a comparison of results will be interesting. The square root of the pressure is 14.1, and five times this is 70.5. The proper thickness according to this rule, therefore, is $\frac{70.5}{1240}$, or about $\frac{1}{17}$th of an inch, which agrees well with the result previously obtained.

It is not always possible to make a float that will meet given requirements as to size and strength, for it must be remembered that a ball, to be of any use, must not only be strong, but must be light enough to *float;* and when the thickness of a ball has been calculated by either of the foregoing methods, the calculator should next make sure that the ball will be light enough to do so. A five-inch ball, spun up from sheet copper $\frac{1}{16}$th of an inch thick, floats about half out of water.

Collapse is not the only thing to be guarded against, in making hollow floats. It is found that water is very apt to enter them when under pressure, probably through minute fissures or cracks or defects in the brazing that the eye does not notice; and in the course of a few months a seemingly good ball may take in so much water as to be worthless. Balls made of light, dry wood, and covered with copper by electrolysis have been tried, but experience shows that enough water will penetrate them to swell up the wood and burst the covering. Sometimes they are set on a hollow stem, which passes out of the tank or boiler through a stuffing box, and which keeps them drained; but the expense of this arrangement and the undesirable friction of the stuffing box has prevented this method from being very widely used. It has also been suggested that a ball filled with air compressed to, say, about 200 lbs. to the square inch, ought to remain dry inside, and not be liable to collapse. Whether the air pressure could be maintained indefinitely is a matter for experiment to determine.

Messrs. Jas. L. Howard & Co., of this city, have adopted the following method of testing copper floats, which seems to be satisfactory. An iron cylinder is filled with the floats to be tested, and a cover is then bolted on the cylinder, which is next filled with water and kept under steam pressure for a week or ten days. At the end of this time the balls are removed, and any that contain water are rejected.

Boiler Explosions.

AUGUST, 1891.

SAW-MILL (?) (139). A stationary boiler on the lease of M. P. Amy, up Sage Run, near Oil City, Pa., exploded on Aug. 2d. Amy was standing in front of the boiler, and was blown through the end of the engine house. By almost a miracle he escaped serious injury, only receiving some burns and a slight strain. The boiler house was demolished, and the boiler blown thirty feet away. The boiler was a second-hand one.

RESTAURANT (140). A boiler in the basement of the building numbered 1173 and 1175 Tremont street, Roxbury, Mass., exploded from some mysterious cause on Aug. 2d, scattering fragments of the brick walls of the building in every direction. The building is two stories in height, the upper portion being composed of wood, while the basement walls are of brick. The rear end of the building was badly wrecked. The building is owned by Robert Treat Paine, and was occupied by Samuel Billings. The damage to building and contents is from \$1,500 to \$2,000, mostly to the building, the injured contents being of an inexpensive nature. Immediately after the explosion the building caught fire, but the flames were soon under control. No one was hurt.

CEREALINE MILLS (141). While a boiler in the large cerealine mills in Columbus, Ind., was being cleaned out on Aug. 2d, another boiler near by bursted, emptying a large volume of steam into the boiler in which John Wagoner was at work, almost cooking him alive. The prompt work of co-laborers rescued Wagoner, but not until he was so badly scalded that he lost the sight of both his eyes, and death may follow. We should judge, from the description, that this was not a true explosion, but that the stop-valve between the boilers gave away.

Box Factory (142). A boiler exploded on Aug. 3d, at the A. Watkins' box factory in Millvale, near Pittsburgh, Pa. The factory and several other buildings were burned, but there were no lives lost. The boiler was blown out of the building, landed 500 feet away in a vacant lot, and from there it bounced into the street. The factory at once caught fire and burned down. Lutz's pickle works also caught fire and was damaged to the extent of $28,000. The houses across the street were damaged to the extent of $3,400. Henry Gerwig will lose $1,000. The loss on the box factory is said to be not over $3,000.

Electric Light Plant (143). On Aug. 3d the Richmond County Light, Heat & Power Company's plant, at Staten Island, N. Y., was destroyed by fire. During the fire one of three boilers exploded, filling the air with pieces of burning timber and other wreckage. Nine large dynamos were destroyed, and the total loss is estimated at $150,000.

Threshing Machine (144). The boiler of a threshing machine and separator, belonging to Joseph Moffett, exploded on August 3d, near Visalia, Cal. The separator, cleaner, and derrick were destroyed, and 150 sacks of wheat burned. Mr. Moffett, who was oiling the machinery at the time, was the only one hurt. He received a cut in the foot.

Threshing Machine (145). On Aug. 3d, a threshing-engine boiler blew up at the farm of Thomas O'Brien, six miles north of York, Neb. The engineer, John McCulloughly, was killed, and four other persons were wounded. The injured are: James Houston, William Turley, Cornelius Keith, and Forest Smith. The separator and all the stacks of grain were fired by the explosion and completely destroyed. The men had just commenced to thresh a small stack of rye and had only been running a few minutes when the explosion occurred. The engine was standing seventy feet west of the separator and the flues and main part of the boiler were thrown about ten feet north of it, landing 75 feet from the engine. Another large piece, weighing about four hundred pounds, was thrown over several tall trees and landed over two hundred feet away. The force of the explosion was terrible, and the engine was scattered over the field in small pieces.

Printing Office (146). The boiler in the press room of the *Alleghany County Democrat* in Wellsville, N. Y., exploded on Aug. 4th. The first side of the paper was just finished, and the foreman, Charles Thorpe, had shut the steam off the engine and turned the gas out under the boiler, when it exploded with terrific force, raising the roof of the building, and doing considerable damage to the engine. The press was not injured, though covered with debris. Thorpe, who was standing within four feet of the boiler, was thrown across the room, badly shaken up, and drenched with hot water and steam; but his injuries were not serious.

Threshing Machine (147). A boiler explosion occurred in a threshing outfit near Healdsburg on Aug. 6th, by which Frank Rippy of Lake county received injuries from which it is thought he cannot recover, and J. P. Crocker was severely, though not fatally, scalded. Several horses were also scalded. The report was heard for miles, and the engine and boiler are a total wreck.

LOCOMOTIVE (148). The boiler of a locomotive exploded in Hammond, Ind., on Aug. 6th. Dennis Conley, the foreman, was thrown 200 feet, and was severely scalded on the face and body. Several pieces of the boiler and engine were found a quarter of a mile from where the explosion occurred.

THRESHING MACHINE (149). Isaiah Curtis, an aged farmer, while assisting in threshing at the barn of Philip Wahers, near Corning, Iowa, on Aug. 7th, was killed by the explosion of the threshing-machine boiler. Charles Morgan, the engineer, was badly injured.

STEAMER (150). By the explosion of a steam pipe on the steamer *Idlewild*, near St. Louis, on Aug. 9th, two colored firemen were killed instantly, and two deck hands, Charles Adams and Marshall Carter, probably fatally injured. A colored passenger was also seriously injured. The cause of the explosion is unknown.

ELECTRIC LIGHT PLANT (151). On Aug. 10th, a boiler exploded in the Bushnell Electric Light Company's plant, Bushnell, Ill., killing two men named Paul and Vannsickle, and wrecking the building. The explosion was exceedingly violent, and did much damage to neighboring buildings.

SAW-MILL (152). The boiler of a portable saw-mill plant belonging to S. S. Meyers, exploded on Aug. 10th. on a tract of land near Mercersburg, Pa. Charles Metcalfe, the engineer, was instantly killed, and several other men were seriously injured.

THRESHING MACHINE (153). A threshing boiler exploded in Litchfield, Minn., on Aug. 12th., and seriously injured two men and killed one horse. Engineer Clements was standing on the footboard and was blown about 20 feet. His right leg was broken below the knee, and the entire leg completely filled with small pieces of iron, so that it will have to be amputated. His head was also bruised, and he may die. Mr. Lund was driving by just as the accident occurred, and one of his horses was killed. Lund's left arm was badly broken and may have to be amputated. The accident occurred in the very heart of the city, and the explosion jarred everything. The front part of the boiler, weighing over 1,000 pounds, was thrown 400 feet.

SHOP BOILER (154). A small boiler in the shop of Artist Charles E. Trippler, at 107th street and West End avenue, New York, exploded on Aug. 18th. Trippler received lacerated wounds of both arms and the right thigh from the flying fragments.

ROLLING MILLS (155). On Aug. 19th, a boiler exploded in Chattanooga, Tenn., at the Lookout Rolling Mills. The explosion came near resulting in the death of Floyd Ramsey, a colored shearman employed at the mill. He was standing near the boiler, and was badly scalded on the body and head by the escaping steam. He was also struck on the left side of the head by a piece of iron, which inflicted a scalp wound from the temple to the back of the head.

SUGAR REFINERY (156). A boiler exploded in the Harrison Sugar Refinery, Philadelphia, on Aug. 20th, seriously injuring Fred Smith, August Hermann, W. Will, Herman Spiering, and Michael Wosserman. The first three were very badly burned about the face and body, the others being less unfortunate, as they were further away. A fire and a dust explosion followed.

THRESHING MACHINE (157). On Aug. 21st, a threshing engine boiler exploded at Cambria, near Lockport, N. Y., destroying the machine and setting fire to a stack of straw. No one was hurt, and no other damage was done.

THRESHING MACHINE (158). A boiler explosion took place in Knox county, eighteen miles southeast of Seymour, Tex., on Aug. 26th, while wheat was being threshed on Mr. Benedict's farm. The boiler was literally torn to pieces, and fragments were thrown several hundred yards away. The following were dangerously injured: Tom Anderson, engineer and owner of the thresher, G. W. Reeves, and a Mr. Hill.

Locomotive (159). The boiler of a locomotive burst at Tazewell Station, near Roanoke, Va., on Aug. 27th, killing Engineer Carpenter instantly, and seriously injuring a Mr. Phillips, who was standing near by. The fireman, who was several feet away, escaped injury. The engine was entirely demolished, but fortunately the explosion occurred at an early hour when the inhabitants of the village were not stirring, so that the fatalities were few.

Donkey Engine (160). The boiler of a large donkey engine exploded at Ben Dixon's ship-yard, Eureka, Cal., on Aug. 27th, fatally injuring four persons. The engine went into the bay 600 feet from where it stood. One person was blown to the deck of a vessel in the bay. The boiler had been in daily use at Matthews' ship-yard for six weeks past. The gauge showed only forty pounds of steam.

Saw-mill (161). On Aug. 27th, the boiler in Nicholas Chambers' saw-mill, six miles southwest of Delaware, O., exploded with terrific force, causing a loss of $2,000. Five men, who were within twenty feet of the engine, miraculously escaped injury.

Steam Yacht (162). A tube gave out on board Col. Cruger's steam yacht *Allegro*, near New York, on Aug. 27th, severely burning James H. Shaw and James T. Haines, engineer and fireman.

Cotton Mather's Letter.

Some time ago a letter was published, which, it was said, was written by Cotton Mather. It was found by a Mr. Judkins, librarian of the Massachusetts Historical Society, so the story goes, while "overhauling a chest of papers deposited in the archives of that body by the late Robert Greenleaf of Malden." The letter, which was described as being in Cotton Mather's handwriting, was marked, "Ye Scheme to Bagge Penne," and read as follows:

"September 15, 1682.

"*To Ye Aged and Beloved*

Mr. John Higginson:

"There be now at sea a ship called *Welcome*, which has on board 100 or more of the heretics and malignants called Quakers, with W. Penn, who is the chief scamp, at the head of them. The General Court has accordingly given secret orders to Master Malachi Huscott of the Brig *Porpoise*, to waylay the said *Welcome* slyly as near the Cape of Cod as may be, and make captive the said Penn and his ungodly crew, so that the Lord may be glorified and not mocked on the soil of this new country with the heathen worship of these people. Much spoil can be made by selling the whole lot to Barbadoes, where slaves fetch good prices in rum and sugar, and we shall not only do the Lord great service by punishing the wicked, but we shall make great good for His ministers and people.

Yours in ye bowels of Christ,

Cotton Mather."

This letter was read in the pulpit by the Reverend Dr. Heber Newton, a short time ago, "as an illustration of the extreme to which religious bigotry can go"; but it was soon learned that Robert Greenleaf was unknown in Malden, and no official of the Massachusetts Historical Society was named Judkins. Of course, this proved the letter to be a hoax, and it has since been learned that Mr. James F. Shunk was its author. It is an old joke, for it first appeared in a somewhat different form in 1870, in the *Easton Argus*, of which paper Mr. Shunk was then editor.

The Locomotive.

HARTFORD, OCTOBER 15, 1891.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

THE LOCOMOTIVE *can be obtained free by calling at any of the company's agencies.*

Subscription price 50 cents per year when mailed from this office.

Bound volumes one dollar each. (Any volume can be supplied.)

Papers that borrow cuts from us will do us a favor if they will mark them plainly in returning, so that we may give proper credit on our books.

THE North German Association for the Supervision of Steam Boilers, sends us a copy of *Vorschläge für die Berechnung der Materialstärken neuer Dampfkessel*, of which we hope shortly to give a review.

IN the August issue of the LOCOMOTIVE, Explosion No. 103, at Theodore Kraan & Bros.' furniture factory, Philadelphia, is said to have been a boiler explosion. Our authority for this statement was the *Philadelphia Times* of June 14th, where it is distinctly described as a boiler explosion; but we have since learned that the *Times* was in error, and that it was an explosion of dust.

A FIRST installment of the vast collection of prehistoric animals, described in our September issue, has reached Washington, and men that are "way up" on bones and fossils are erecting them in the National Museum. Some idea of the size of the collection may be had from the fact that Professor Marsh has enough giant lizards alone to half fill the great building of the Smithsonian Institution.

WE have received from the publisher, Mr. John A. Hill, Box 1736, New York, a copy of an excellent little book written by himself, and entitled *Progressive Examinations of Locomotive Engineers and Firemen.* Mr. Hill, as he says, "has served ten years on the foot-board," and his book has additional value on that account. The questions and answers are clear, sensible, and instructive; and the diagrams illustrating the use of signals, which follow the examinations, ought to make this subject plain to any body. The price of the book, fifty cents, puts it in the reach of every one.

MR. John Henney, Superintendent of Motive Power on the N. Y., N. H. & H. R. R., writes to say that our account of explosion No. 131, in the September LOCOMOTIVE, is not quite correct. "The engine," he says, "blew out a plug in the flue sheet that was used in cleaning out the dirt below the flues. There was no explosion, the engine being at work three hours afterwards with a new plug in the place of the old one." We have to rely largely on newspaper accounts in making up our monthly list of explosions, and although we endeavor to have the list correct as far as may be, our source of information is sometimes in error as to details.

The Yorkshire Boiler Insurance Company of Bradford, Eng., send us a copy of Mr. John Waugh's report on the explosion of an upright boiler at Huddersfield, Eng., on June 3, 1891. The boiler was internally fired, and a hammer test was applied to it (not by the Yorkshire company, however) on June 2d, the day before the explosion. Next day, the fire-box collapsed, killing one man and injuring several others. The rupture revealed the fact that for a distance of six to eighteen inches from the bottom of the firebox, corrosion had eaten the plate away round the whole circumference of the boiler; in some places, about 13 or 14 inches from the bottom, to the thickness of $\frac{1}{16}$, the original thickness being $\frac{7}{16}$ of an inch.

This explosion is an excellent illustration of one very important fact, which is, that the hammer test, to be of value, must be applied by a man who has had long experience in such work. A novice might pass over a very dangerous spot with the hammer, and not detect it ; while, on the other hand, we have seen experienced inspectors detect flaws with the hammer where the novice could perceive no difference in the sound. We do not recommend the hammer as a substitute for thorough internal and external examination, but it is very valuable when applied by an experienced person, on boilers that cannot be thoroughly examined in any other way, either on account of their design or their small size: and we believe in applying it on every occasion, in *addition* to the regular internal examination.

Testing Mt. Washington Engines.

Mr. Charles W. Aiken, of the Massachusetts Institute of Technology, made a series of tests of the Mount Washington engines last year, for the results of which, as given below, we are indebted to Mr. W. H. Allen, assistant manager of our northeastern department.

Number of Test.	2	3	4	5	6
Duration of test (minutes), . .	71.5	67.5	76.5	86.5	73.5
Mean horse-power, ...	84.49	94.40	95.50	58.08	91.58
Wood burned (in pounds), . .	. . .	1,871	2,378	1,571	2,210
Wood per hour, ...	. . . .	1,663	1,865	1,090	1,804
Wood per sq. foot of grate per hour,	. . . .	183.0	205.2	120.0	198.5
Wood per horse-power per hour,	. . . .	17.7	19.5	18.8	19.7
Total water evaporated, . .	4,916	5,506	5,669	3,347	5,046
Water evaporated per hour, .	4,131	4,873	4,107	2,615	4,103
Water per horse-power per hour,	47.3	50.3	41.1	43.3	43.3
Water per pound of wood, . .	. . . .	2.93	2.20	2.40	2.27
Estimated load (pounds), . .	29,000	30,000	31,000	20,000	30,000
Maximum horse-power developed,	128.39	116.92	122.11	78.80	124.15

Remarks.

Test No. 1 was incomplete, and was not recorded.

Test No. 2 was made with a freight car loaded with wood and ice; noon trip.

Test No. 3 was made with a passenger car and baggage car, 25 passengers; evening train.

Test No. 4 was made with a passenger car, "big car"; 54 passengers, but no baggage car; morning train.

Test No. 5 was made with engine alone; noon.

Test No. 6 was made with a passenger car, a baggage car, and 27 passengers.

Tests were also made on the down trips corresponding to tests Nos. 4 and 5. The mean horse-power developed on the down trip, test No. 4, was 81.84. Mean horse-power, down trip, test No. 5, 38.24.

On test No. 5, 1,633 pounds of wood were burned on the round trip. On test No. 6, 2,743 pounds of wood were burned on the round trip, including a trip back to "Lizzie's" for water, and also including the wood for building the fire in the morning.

White Mountain Notes.

BRANCH OFFICE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.,
35 PEMBERTON SQUARE, BOSTON, MASS.

EDITOR LOCOMOTIVE: On the afternoon of Sept. 14th, I went up Mt. Washington by stage with a party from the Glen House, which, by the way, is one of the most attractive and best kept hotels in the mountains. It was very warm at the hotel when we started, but began to grow cool as we approached the summit. When about a mile from the Summit House, a furious storm of wind and sleet came down upon us, and the darkness was like that of midnight. It was with difficulty that the driver could keep the horses in the road. We arrived at the Summit House thoroughly drenched, and benumbed with cold. Icicles were pending from hair and beard. A cheerful wood fire in a large open fireplace was a grateful welcome. I slept soundly that night and arose early the next morning to see a clear sky and later a superb sunrise. Enclosed is a clipping from *Among the Clouds*, which may interest the readers of the LOCOMOTIVE.

WILLIAM H. ALLEN.

HISTORICAL EVENTS RELATING TO THE WHITE MOUNTAINS.

Little is known regarding the White Mountains before the year 1642, when Darby Field of Portsmouth made the first ascent of Mount Washington. Indian tribes then lived near the mountains, and but few of their traditions have been preserved. Their name for the mountains was Waumbek Methna, and for Mount Washington Agiochook. John Josselyn in his book "New England Rarities Discovered," published in 1672, gave the first description of the mountains. The White Mountain Notch was discovered by two hunters, Nash and Sawyer, in 1771. The first settlements among the mountains were made in the latter half of the last century, Conway being settled in 1764, Franconia in 1774, Bartlett in 1777, Jackson in 1778, and Bethlehem in 1790.

Capt. Eleazur Rosebrook made the first settlement at the site of the Fabyan House in 1792. He opened there, in 1803, the first house for summer visitors ever kept in the mountains. His son-in-law, Abel Crawford, long known as the "Patriarch of the Mountains," settled later what is now called Bemis Station in 1793. The latter's son, Ethan Allen Crawford, the most famous of the mountain pioneers, took Rosebrook's house in 1817. In 1819 he opened the first foot-path up Mount Washington. His brother, Thomas J. Crawford, opened the first bridle-path to the summit in 1840, and his father, then 75 years old, rode the first horse that ever climbed the mountain. The first hotel on Mount Washington was the old Summit House, built in 1852. The Tip-Top House was built in 1853, and the present Summit House in 1872. The old Summit House was torn down in the spring of 1884, to give place to a new building, used as lodging-rooms for the employés of the hotel. The first winter ascent of Mount Washington was made by the sheriff of Coos County and B. F. Osgood of Gorham, December 7, 1858. John H. Spaulding, Franklin White, and C. C. Brooks of Lancaster, made the ascent February 19, 1862, and were the first to spend the night on the mountain in winter.

The carriage road from the Glen House to the summit of Mount Washington was begun in 1855, under the management of D. O. Macomber, C. H. V. Cavis being surveyor. The first four miles were finished the next year. Financial troubles stopped the work for a time, but the road was finally opened August 8, 1861. George W. Lane, now in charge of the Fabyan House stables, drove the first Concord coach that ever ascended Mount Washington, August 8, 1861, on the opening of the carriage road. It contained J. M. Thompson, then proprietor of the Glen House, and his family. The Mount Washington railway was projected by Sylvester Marsh. The building of the road was begun in 1866 and finished in 1869.

The signal station at the summit was established in 1870. Prof. J. H. Huntington of the state geological survey was at the head of the party that spent the first winter, having with him Sergeant Theodore Smith of the signal service, and S. A. Nelson of Georgetown, Mass. The building now occupied by the observers was erected in 1873.

The first number of *Among the Clouds*, which was the first daily newspaper published in the White Mountains, and the only one printed on any mountain in the world, was issued July 18, 1877, by Henry M. Burt of Springfield, Mass. Its publication has suggested all the other summer resort papers that have been established.

MOUNTAIN TRAGEDIES.

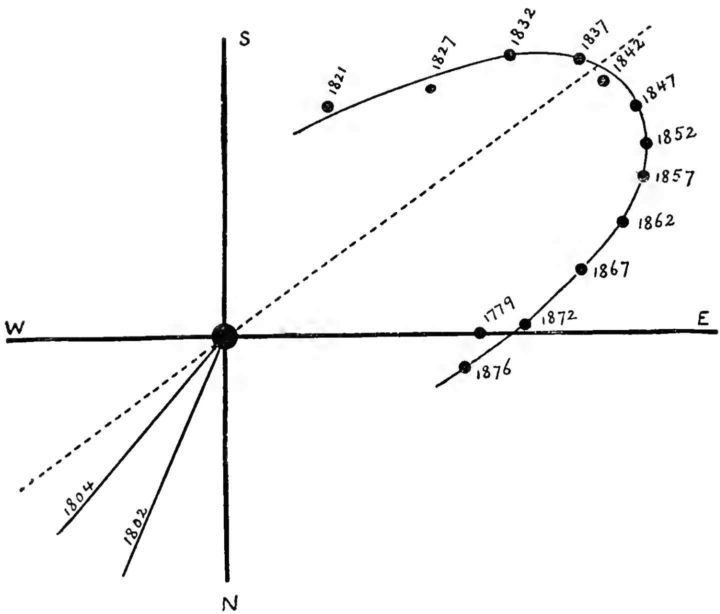
The destruction of the Willey family by a land side in the White Mountain Notch, occurred August 28, 1826. Frederick Strickland, an Englishman, perished in the Ammonoosuc Ravine in October, 1851. Miss Lizzie Bourne of Kennebunk, Me., perished on the Glen bridle-path, near the summit, on the night of September 14, 1855. Dr. B. L. Ball of Boston was lost on Mount Washington in October, 1855, in a snow storm, but rescued after two days' and nights' exposure, without food or sleep. Benjamin Chandler of Delaware perished near Chandler's Peak, half a mile from the top of Mount Washington, August 7, 1856, in a storm, and his remains were not discovered for nearly a year. Harry W. Hunter of Pittsburgh, Pa., perished on the Crawford bridle-path September 3, 1874, a mile from the summit. His remains were found nearly six years later, July 14, 1880. Sewall E. Faunce, 15 years old, son of Sewall A. Faunce of Boston, was killed in Tuckerman's Ravine, Saturday, July 24, 1886, at 2 P. M., by the falling of the snow arch. His body was recovered and carried to the summit by a relief party made up of employés of the Summit House, stage office, office of *Among the Clouds*, and the officers of the United States signal station. He was with a party from Grove Cottage near Gorham, who had walked into the ravine from below, and the arch fell while they were near it. Another member of the party, Miss Maggie Pierce of New Bedford, was also partly buried by the falling arch and slightly injured. She was carried down the path to the Glen House. Ewald Weiss of New Haven, Conn., left the Summit House on Sunday morning, August 24, 1890, for a walk to the summit of Mount Adams and return. He has not been seen or heard from since that time, and it is believed that he perished on the peaks or in the ravines. He was a native of Germany, and at the time of his departure was a violinist in the Summit House orchestra.

FOREIGN STEAMER. The boiler in the Danube Steamship Company's steamer *Apostag* exploded near Neusatz, a town on the Danube, on Aug. 24th, killing five people and seriously injuring two others.

ACCIDENT ON A STEAM LAUNCH. On Aug. 26th, a safety-valve gave away on the steam launch *M. J. Tracey*, as she lay at the foot of Richards street, Brooklyn. William McGibbon, the engineer, was terribly scalded by steam and water.

Double Stars.

For many years it has been known that some of the stars that appear single to the naked eye, in reality consist of two or more stars, which can be seen separately in the telescope. Between the years 1779 and 1784, Sir William Herschel made extensive catalogues of these objects, because he thought it likely that they were only *optically* double, one being really much more remote than the other, the proximity being apparent to us because the two lie almost in the same line with us. If that were the case, the earth's motion to and fro about the sun might be great enough to make an appreciable variation in the distance or the direction of one star from the other. So, after making an extensive catalogue of them, recording their distances and directions, he began to go over them again to see if the distances or directions had changed, when, as his son says, "his attention was altogether diverted from the original object of the



APPARENT ORBIT OF THE STAR 70 OPHIUCHI.

inquiry by phenomena of a very unexpected character, which at once engrossed his whole attention." Instead of finding an annual and alternate increase and decrease of their distance and direction, he saw that in many cases there was a progressive change in both, advancing steadily in one direction. Now this might arise from a swift progressive motion of the solar system through space, or it might be that the two stars have motions of their own. There are good reasons for believing that our sun has no very rapid motion through space, that is, we are pretty well satisfied that he does not move through space much more than half as fast as the earth moves in her orbit. It is likely, therefore, on general considerations, that the stars have motions of their own. No matter whether the visible changes were due to the sun's motion or to the motions of the stars; if all three were separated by exceedingly vast distances, we should expect the visible changes in position of the stars to progress uniformly as though the sun and each star were moving in straight lines. After the lapse of about twenty-five years, Herschel became satisfied that many of his stars are *not* moving in straight lines, and in 1802, he announced that "there exist sidereal systems, composed of two stars revolving about each other in regular orbits," in the same manner that the earth revolves about the sun, or the moon about the earth.

Since Herschel's time, a great multitude of measurements of binary stars have been made, and it has been found possible to calculate the orbits of many of them. The cut illustrates one of these orbits — that of the star known to astronomers as 70 *Ophiuchi*. The large spot in the center represents the principal star of the two, and the other spots show the position of the companion star at the various dates appended. The heavy vertical and horizontal lines show the points of the compass, and the following table gives the measurements that had been published up to the beginning of 1878. The measures are averaged together, dates and all, so as to fall as nearly as possible in groups about five years apart. The columns headed "Number of Nights," give the number of separate nights on which observations were made during the period represented by the measures opposite.

Average Date.	Angle.	Distance.	No. of Nights.	Average Date.	Angle.	Distance.	No. of Nights.
1779.76	90.0°	3.60″	1	1847.30	119.3°	6.68″	54
1802.25	336.1	....	1	1852.92	114.5	6.54	97
1804 41	319.0	....	1	1857.37	110.7	6.33	85
1821.31	156.2	3.68	1	1862.59	105.6	5.88	76
1827.33	140.3	4.53	28	1867.50	100.2	5.13	83
1832.05	134.6	5.69	48	1872.45	91.6	4.25	152
1837.47	128.1	6,39	42	1876.67	82.0	3.41	49
1842.55	123.9	6.45	71				

The angles in the second and sixth columns are measured from north around through east, in the direction opposite to the motion of the hands of a clock. Unfortunately, Herschel did not measure the distance between the two stars either in 1802 or in 1804, so we have not marked the positions of the companion star for these years in the cut. These positions can be calculated from the orbit given below ; but so far as observation goes, we only know, that in these years the companion star was somewhere on the full lines marked 1802 and 1804 respectively.

It will be seen that between Herschel's first measure in 1779, and the measure given for 1872, the companion star had passed almost all the way around its primary, so that the period of revolution of the star must be about 93 years (1872−1779=93). In fact, M. Schur finds, by a mathematical analysis, that the period is 94.37 years.

Of course, we cannot suppose that the plane of the star's orbit is perpendicular to our line of sight, and M. Schur finds, in fact, that the angle between the two is 32° 06′. There must be one line in the orbit, however, which is perpendicular to our line of sight, and this, which is called the "line of nodes," is shown in the cut by the dotted line. M. Schur's complete elements of the orbit are as follows: Date of the star's last passage through perihelion = 1808.79 ; angle, in the orbit, between perihelion and "line of nodes" = 155° 42′ ; apparent angle on the heavens between north and south line and the "line of nodes" 125° 24′ ; inclination of orbit to line of sight = 32° 06′; eccentricity of orbit = 0.49149; mean distance between the two stars = 4.704″; time of one revolution = 94.37 years.

There are many other systems similar to this one in the heavens, and there are some consisting of three or more stars, each revolving about the center of gravity of all.

Imagine the state of things on a planet circulating about *ι Cancri*, where a blazing yellow sun may rise at nine o'clock, and as evening of the yellow day comes on, a beautiful blue sun rises above the horizon; objects illuminated by both suns might be white, while the blue sun might cast a yellow shadow, and the yellow sun a blue one. And again, what would be the sensation of a stranger on some planet in *Andromedæ's* family, when, just after the setting of a magnificent crimson sun in the east, he should behold the rising of a *pair* of gorgeous green suns in the west! We might also have a red and a green day alternating with a white one and with darkness, according as one sun or the other, or both, or neither, was above the horizon. Of course, the complementary colors of some of the double stars may be only apparent, and due to contrast as we see them so closely together in the field of our telescope; but we have no positive knowledge that this is the fact.

Another interesting thing about the double stars whose orbits are known, is that these orbits are very nearly true ellipses. We say this is interesting, because we have grown so familiar with Newton's law of gravitation here in our petty family of planets, that we have come to think that it is a sort of necessary law that gravitation should be inversely proportional to the second power of the distance. Now, until the double stars were examined, that had never been proven to be even approximately so in any part of all the infinity of space, except the little corner that we occupy. But since the orbits of these remote suns are very nearly ellipses, it follows that Newton's law is, at least, very nearly correct in those more distant spots in space, as well as here; and that leads us to suppose that the law is very closely true over vast regions of space that we previously knew nothing about.

The Colorado Desert Lake.

Mr. J. J. McGillivray, who has been for many years in the United States mineral survey service, has some interesting things to say about the overflow of the Colorado desert, which has excited so much comment, and about which so many different stories have been told.

"None of the papers, so far as I know," said Mr. McGillivray, "have described with much accuracy or detail the interesting thing which has happened in the Colorado desert, or have stated how it happened. The Colorado desert lies a short distance northwest of the upper end of the gulf of California, and contains not far from 2,500 square miles. The Colorado river, which has now flooded it, has been flowing along to the east of it, emptying into the gulf of California. The surface of the desert is almost all level and low, some of it below the sea level. Some few hundreds of years ago it was a bay making in from the gulf of California, and then served as the outlet of the Colorado river. But the river carried a good deal of sediment, and in time made a bar, which slowly and surely shut off the sea on the south, leaving only a narrow channel for the escape of the river, which cut its way out, probably at some time when it was not carrying much sediment. Then the current became more rapid, and cut its way back into the land, and, in doing this, did not necessarily choose the lowest place, but rather the place where the formation of the land was soft, and easily cut away by the action of the water.

"While the river was cutting its way back, it was, of course, carrying more or less sediment, and this was left along the banks, building them all the time higher, and confining the river more securely in its bounds. That is the Colorado river as we have known it ever since its discovery. Meantime, the water left in the shallow lake, cut off from the flow of the river, gradually evaporated — a thing that would take but a few years in that country, where the heat is intense and the humidity very low. That left somewhere about 2,000 miles of desert land, covered with a deposit of salt from the sea water which had evaporated, and most of it below the level of the sea. That is the Colorado desert as it has been known since its discovery.

"Then, last spring, came the overflow which has brought about the present state of affairs. The river was high, and carrying an enormous amount of sediment in proportion to the quantity of water. This gradually filled up the bed of the stream and caused it to overflow its banks, breaking through into the dry lake where it had formerly flowed. The fact that the water is salt, which excited much comment at the time the overflow was first discovered, is, of course, due to the fact that the salt in the sea water which evaporated hundreds of years ago has remained there all the time, and is now once more in solution.

"The desert will, no doubt, continue to be a lake and the outlet of the river unless the breaks in the banks of the river are dammed by artificial means, which seems hardly possible, as the river has been flowing through the break in the stream 200 feet wide, four feet deep, and flowing at a velocity of five feet a second.

"It is an interesting fact to note that the military survey made in 1853 went over this ground and predicted the very thing which has now happened. The flooding of the desert will be a good thing for the surrounding country, for it does away with a large tract of absolutely useless land, so barren that it is impossible to raise there what the man in Texas said they mostly raised in his town, and it will increase the humidity of the surrounding territory. Nature has done with this piece of waste land what it has often been proposed to do by private enterprise or by public appropriation. Congress has often been asked to make an appropriation for that purpose."

Mr. McGillivray had also some interesting things to say about Death Valley, which he surveyed.

"It has been called a *terra incognita* and a place where no human being could live. Well, it is bad enough, but perhaps not quite so bad as that. The great trouble is the scarcity of water and the intense heat. But many prospecting parties go there looking for veins of ore, and to take out borax. The richest borax mines in the world are found there. The valley is about 75 miles long by 10 miles wide. The lowest point is near the center where it is about 150 feet below the level of the sea. Just 15 miles west of this central point is Telescope peak, 11,000 feet above the sea, and 15 miles east is Mt. Le Count, in the Funeral mountains, 8,000 feet high. The valley runs almost due north and south, which is one reason for the extreme heat. The only stream of water in or near the valley flows into its upper end and forms a marsh in the bed of the valley. This marsh gives out a horrible odor of sulphuretted hydrogen, the gas which makes a rotten egg so offensive. Where the water of this stream comes from is not very definitely known, but in my opinion it comes from Owen's lake, beyond the Telescope mountains to the west, flowing down into the valley by some subterranean passage. The same impurities found in the stream are also found in the lake, where the water is so saturated with salt, boracic acid, etc., that one can no more sink in it than in the water of the Great Salt lake; and I found it so saturated that after swimming in it a little while the skin all over my body was gnawed and made very sore by the acids. Another reason why I think the water of the stream enters the valley by some fixed subterranean source is the fact that, no matter what the season, the flow from the springs that feed the marsh is always exactly the same.

"The heat there is intense. A man cannot go an hour without water without becoming insane. While we were surveying there, we had the same wooden cased thermometer that is used by the signal service. It was hung in the shade on the side of our shed, with the only stream in the country flowing directly under it, and it repeatedly registered 130°; and for 48 hours in 1883, when I was surveying there, the thermometer never once went below 104°."— *Boston Herald.*

The Locomotive.

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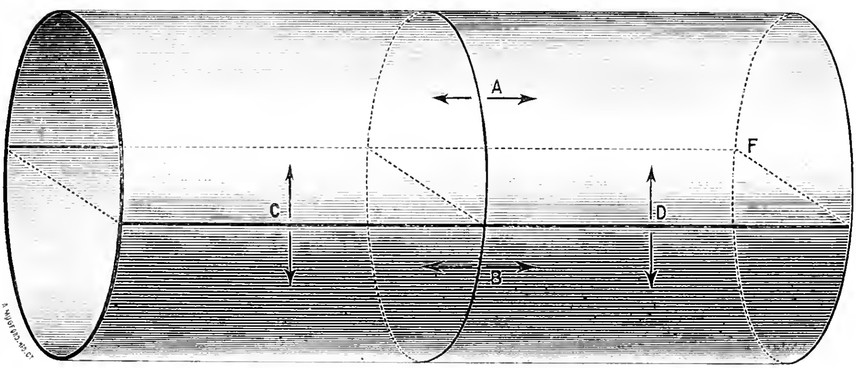
Longitudinal and Girth Joints in Boilers.

All writers upon the subject of steam boiler design devote considerable space to the discussion of the longitudinal joints, but it has appeared to some of our readers that the girth joints have not received sufficient attention. For example, in boilers that are to withstand high pressures, the longitudinal joints are now usually made by abutting the plates, and securing one or two overlapping straps to the plates by means of two rows of double or triple riveting; while the girth joints on the same boiler are ordinary, single-riveted lap joints. It is the purpose of the present article to make it plain that this construction is correct, and that if the single-riveted girth joint is properly designed, it is still considerably stronger than the double butt-strap, triple-riveted longitudinal joint.

The cut represents a hollow cylinder of steel, an ideal boiler shell, without heads or joints. It is 66 inches in diameter, and 14 feet long. The thickness of the metal is $\frac{3}{8}$



LONGITUDINAL VS. GIRTH JOINTS IN BOILERS.

of an inch, and its tensile strength, let us say, is 55,000 lbs. per square inch of section. If this shell is burst by steam or water pressure, the fracture can run longitudinally, along the lines *E F D C*, or around the boiler, along the line *B A*.

Let us first find the bursting pressure, assuming that the fracture takes place longitudinally. At the moment of rupture, the strain on the metal must be just equal to its tensile strength; that is, to 55,000 pounds per square inch. The area of plate to be broken, along the line *C D*, is $168 \times \frac{3}{8} = 63$ square inches, 168 being the length of the boiler in inches, and $\frac{3}{8}$ being the thickness. The section along *E F* has the same area, so that the total area to be broken across is $2 \times 63 = 126$ square inches; and since the strain on each square inch is 55,000 pounds at the moment of rupture, the total strain on the section of rupture will be $126 \times 55,000 = 6,930,000$ lbs.

The total steam pressure tending to force the two halves of the boiler apart is equal to the pressure per square inch multiplied by the area of the cross-section of the boiler. which area, in this case, is 168 (length of boiler) × 66 (diameter of boiler) = 11,088 square inches. Those who are not familiar with this sort of calculation sometimes find it hard to understand why the surface of the shell is not used, instead of the area of cross-section. The answer is, that the pressure on the half *E A D*, for example, does not all act in the same direction, owing to the curvature of the shell. The pressure on parts that are close to the line *C D* acts almost horizontally, while on the parts lying along the top of the boiler it acts vertically. It would be easy to take these varying directions into account, but the same result can be reached without any figures, and in a very simple way. Suppose, for example, that the lower half of the boiler in the cut should be taken away, and that a flat plate should be bolted to the upper half in its place. If steam is now admitted, experience tells us that the boiler will not move either up or down; and it follows from this that the pressure against the curved half of the structure is precisely equivalent, so far as forcing the halves of the boiler apart is concerned, to that against the flat plate bolted to it. Hence, as was stated in the first part of this paragraph, the total pressure tending to force the two halves of the boiler apart is equal to the pressure per square inch, multiplied by the area of cross-section of the boiler (11,088 square inches).

The pressure that would burst a shell like that shown in the cut is of such a magnitude, therefore, that if it is multiplied by 11,088 sq. in. (the area on which it acts) the product will be 6,930,000 pounds. Hence the bursting pressure is 6,930,000 ÷ 11,088 = 625 lbs. per square inch. This is not the bursting pressure of a *boiler* of this size, but simply of a steel shell of the given dimensions; for we have not yet taken account of the joints that occur in boilers.

Let us now see what pressure would be required to force the boilers apart endwise, tearing it along the line *A B*. The only thing that can produce a strain acting lengthwise along the boiler, is the pressure on the head, which is equal to the steam pressure per square inch, multiplied by the area of the head, the area of the head in the present case being 66 × 66 × .7854 = 3,421 sq. in.

To withstand the strain so produced we have a ring of metal at *A B*, which is 207.3 inches in circumference (66 × 3.1416 = 207.3), and $\frac{3}{8}$ of an inch thick. The area of this ring is 207.3 × $\frac{3}{8}$ = 77.74 sq. in.; and when the shell is about to break, the strain upon the section *A B* will be 55,000 × 77.74 = 4,275,700 lbs. When the boiler parts, therefore, the steam pressure must be such that, by acting on an area of 3,421 sq. in., it produces a resulting strain of 4,275,700 lbs. Hence the bursting pressure per square inch is 4,275,700 ÷ 3,421 = 1,250 lbs.

The results that we have thus far reached are, that it would take a steam pressure of 625 pounds per square inch to rupture a shell of the given dimensions longitudinally, and that it would take precisely twice this pressure, or 1,250 pounds per square inch, to rupture it circumferentially.

If the shell were made up of plates, riveted together, we should have to modify the foregoing calculation somewhat, so as to take account of the diminished strength due to the existence of the joints. Let us suppose there is a single-riveted girth joint whose dimensions are as follows: Diameter of rivets $\frac{3}{4}$ inch; diameter of rivet holes, $\frac{13}{16}$ inch; pitch of rivets, $1\frac{3}{4}$ inches; tensile strength of plate, 55,000 lbs. It will be found that this joint has 53 per cent. of the strength of the solid plate; so that the pressure per square inch that would rupture such a shell circumferentially, so as to blow the two ends apart, would be 53 per cent. of 1,250 lbs. 1,250 × 53 = 662.5. It would therefore take a pressure of $662\frac{1}{2}$ lbs. to the square inch to pull this girth joint apart. But from our previous calculation it appeared that a pressure of 625 lbs. would tear the *solid plate* apart lengthwise; so that it appears that the solid plate would tear longitudinally before a properly proportioned single-riveted girth joint would fail. This is ample justification for the use of single-riveted girth joints even when the longitudinal joints are butted and strapped and triple riveted.

Let us suppose that the boiler has triple riveted butt-strap joints, such as were described in THE LOCOMOTIVE for July, 1891, the dimensions of the joints being as follows: Strength of plate = 55,000 lbs. per square inch; thickness of plate = $\frac{3}{8}$ inch; diameter of rivet holes = $\frac{13}{16}$; pitch of inner rows of rivets = $3\frac{1}{4}$ inches; pitch of outer rows = $6\frac{1}{2}$ in. In the issue of THE LOCOMOTIVE cited above the efficiency of this joint is shown to be 87.5 per cent. The pressure that would rupture the solid shell longitudinally being 625 lbs., the pressure that would rupture a similar shell with a longitudinal joint proportioned as above would be 87.5 per cent. of 625 lbs., which is 547 lbs.; and the safe working pressure, allowing the usual factor of safety of 5, would be 547 ÷ 5 = 109 lbs. per square inch.

To illustrate the fact that a single-riveted girth joint is stronger than any form of longitudinal joint, we have taken a particular case and computed the strength in both directions. A general proof of the same fact might be given, applicable to all diameters of boilers, all thicknesses of metal, and all styles of joints; but the proof would be algebraical, and for this reason we have not thought it necessary to include it. Those of our readers who understand algebra will have no difficulty in finding the general proof for themselves, for it is based upon precisely the same considerations as the numerical example given above.

Inspectors' Reports.

JULY, 1891.

During this month our inspectors made 6,177 inspection trips, visited 11,997 boilers, inspected 6,585 both internally and externally, and subjected 732 to hydrostatic pressure. The whole number of defects reported reached 12,007, of which 906 were considered dangerous; 49 boilers were considered unsafe for further use. Our usual summary is appended:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,222	49
Cases of incrustation and scale,	1,565	48
Cases of internal grooving,	100	17
Cases of internal corrosion,	598	33
Cases of external corrosion,	817	21
Broken and loose braces and stays,	160	47
Settings defective,	338	34
Furnaces out of shape,	419	23
Fractured plates,	217	74
Burned plates,	221	26
Blistered plates,	466	10
Cases of defective riveting,	2,377	120
Defective heads,	105	17
Serious leakage around tube ends,	1,741	187
Serious leakage at seams,	363	44
Defective water-gauges,	310	30
Defective blow-offs,	115	19

Nature of Defects.	Whole Number.	Dangerous.
Cases of deficiency of water,	13	8
Safety-valves overloaded,	74	17
Safety-valves defective in construction,	80	15
Pressure-gauges defective,	588	55
Boilers without pressure-gauges,	10	10
Unclassified defects,	108	2
Total,	12,007	906

August, 1891.

During this month our inspectors made 5,644 inspection trips, visited 10,398 boilers, inspected 4,697 both internally and externally, and subjected 619 to hydrostatic pressure. The whole number of defects reported reached 9,236, of which 626 were considered dangerous; 43 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	847	58
Cases of incrustation and scale,	1,169	51
Cases of internal grooving,	94	8
Cases of internal corrosion,	391	15
Cases of external corrosion,	758	38
Broken and loose braces and stays,	103	36
Settings defective,	220	13
Furnaces out of shape,	305	19
Fractured plates,	162	33
Burned plates,	131	24
Blistered plates,	264	10
Cases of defective riveting,	2,003	76
Defective heads,	74	18
Serious leakage around tube ends,	1,433	82
Serious leakage at seams,	354	31
Defective water-gauges,	314	31
Defective blow-offs,	83	21
Cases of deficiency of water,	8	5
Safety-valves overloaded,	39	14
Safety-valves defective in construction,	46	15
Pressure gauges defective,	363	13
Boilers without pressure gauges,	0	0
Unclassified defects,	75	15
Total,	9,236	626

Boiler Explosions.

September, 1891.

Distillery (163). The boiler in the Rugby distillery, in Portland, Ky., exploded Sept. 1st.

Mine (164). The boiler of the engine of the old shaft at Pratt mines, Birmingham, Ala., exploded on Sept. 1st, killing Emanuel Wiggins, the nineteen-year-old fireman. Wiggins was instantly killed, his body being blown a considerable distance. The boiler was an old one, and was used for pumping water out of the mines.

THRESHER (165). By the explosion of a threshing machine boiler in Cherokee, Iowa, on Sept. 2d, Ed. Fitts was badly scalded, and was blown 200 feet through the air. Fitts died from his injuries within a few days.

MINE (166). A boiler exploded at Granby, Mo., on Sept. 3d, which resulted in the death of two boys, Jimmy Norborge, aged 6, and Ed. Stanford, aged 9. It was about dark, and the miners at a shaft of the Granby Company had quit work, the engineer leaving the engine with the boiler full of water and forty pounds of steam. The two boys remained there playing. About fifteen minutes after the men left, the boiler exploded. The two boys, who were several yards away, were blown into the air and received injuries from which both died.

PRINTING OFFICE (167). The three-horse-power upright boiler in the Herald Printing House, No. 1621 Carson Street, Pittsburgh, Pa., exploded on Sept. 4th. The boiler furnishes power to the presses, and Frank Worling, a pressman, was in the act of starting the engine, when the tube sheet blew out of the boiler, and he was badly scalded about the legs. No damage was done to the engine or building. The supposition is, that the plate was cracked.

LOCOMOTIVE (168). On Sept. 9th, Locomotive No. 113, on the Long Island Railroad, burst her boiler at the Oyster Bay station. James Donaldson, engineer, Townsend Dickerson, fireman, and Michael Mahoney, brakeman, were instantly killed. Alfred Jones, the conductor, was badly scalded and bruised, and Edward Swan received painful injuries from a flying bolt.

RUBBER FACTORY (169). At the Globe Rubber Works belonging to Brooks, Oliphant & Co., on Prospect Hill, Trenton, N. J., a vulcanizer weighing ten tons, and filled with pans of shoddy rubber, exploded on Sept. 15th. Big fragments of the vulcanizer flew through the room, and one of them struck Caleb Bennett in the head. He died soon afterward at St. Francis Hospital. The accident occurred during the noon hour, when nearly all the employes were absent. The shock was felt a mile away; all the windows in the factory were smashed, and a great deal of damage to machinery done. The vulcanizer was run by steam, but only the ordinary pressure, it is said, was used.

SAW-MILL (170). The boiler in Whittington's saw-mill, Warren, Ark., exploded on Sept. 17th. Will Whittington had his arm and jaw broken, and was fatally injured internally. A little boy and a negro man were badly scalded and otherwise injured. Sections of the boiler were blown 200 yards from the yard.

THRESHER (171). On Sept. 18th, the steam boiler of a portable threshing machine belonging to Arch Porter, while at work at the McConnell farm in Cross Creek township, three miles west of Steubenville, O., exploded, wrecking the threshing machine. Frank Maxwell was seriously scalded. Arch Porter, Thomas Quillen, Henry Perman, and Alexander Clifton were also scalded.

JELLY MANUFACTORY (172). On Sept. 18th, a boiler exploded in Vansise's jelly factory, in the town of Montville, ten miles from Chardon, Ohio. The building was completely wrecked, and three workmen and two little girls were killed.

THRESHER (173). On Sept. 19th, while a steam threshing machine was in operation at H. H. Witherill's, two miles from Depeyster, N. Y., the boiler exploded, instantly killing Willie Warren. The explosion broke every window in the side of the Witherill house, and the report was heard for miles. A little girl who was standing in the window of the house at the time was knocked down and cut slightly by the broken glass. Ira Link, who was near the machine, was also knocked down, but was not injured. The dome of the boiler, weighing about 125 pounds, was blown 260 feet away. Warren's body was picked up 45 feet away from the engine.

THRESHER (174). The boiler of the threshing machine outfit of H. Schubert exploded on Sept. 22d, at the Griffin ranch, fourteen miles east of Monument, Colo. Edward Dyker, the engineer, was instantly killed by fragments of boiler iron striking him and crushing his breast and legs. John Kunze, a water hauler, was badly scalded in the face by the escaping steam, and two horses hitched to the water wagon were killed.

SAW-MILL (175). A terrible boiler explosion took place on Sept. 24th, in Berlin's new saw-mill at Bear Creek, Kingsley township, twelve miles from Tionesta, Pa. The mill was totally demolished, pieces of timber, lumber, parts of the boiler and human bodies being thrown many feet away. J. Elva Berlin, owner of the mill, and James Conger and Charles B. Grove were killed. Two other men, who were working at the far end of the mill, were blown from their feet, but escaped unharmed.

SHINGLE MILL (176). The boiler in the shingle and bolt factory owned by James Wilhite, at Darlington, Ind., exploded on Sept. 25th, and Wesley Philips, the engineer, was terribly injured. He was thrown fifty feet away by the force of the concussion. Other employes were slightly injured, and the mill was wrecked.

SAW-MILL (177). On Sept. 25th, a boiler exploded in David Comack's saw-mills, at Mulberry, near Muncil, Ind. The building was demolished, but none of the employes were seriously injured.

Number of Bricks in Boiler Settings.

The accompanying table will be found serviceable in estimating the number of bricks required for settings. The first column gives the diameter of the boiler, the second gives the length of the boiler tubes, the third gives the kind of front the boiler is to have, flush fronts requiring more brick than over-hanging fronts. The fourth and fifth columns give the number of common bricks and fire bricks, respectively, that are required to set a single boiler of the given diameter, length of tube, and style of front. The sixth column gives the number of bricks that must be added for each foot in length that the tubes in a proposed boiler exceed the standard length given in the table. The seventh column gives the number of bricks that must be added for each additional boiler after the first. The eighth, or last, column gives the number of bricks that must be added for each boiler after the first, for each foot that the tube-length exceeds the standard length given in the table. A few examples will make the use of the table plain.

EXAMPLE 1. How many bricks will be required to set a fifty-four-inch boiler, with tubes 15 feet long: overhanging front? *Ans.* The table gives the number at once, *viz.*, 16,700 common brick, and 886 fire-brick.

EXAMPLE 2. How many bricks will be required to set a flush front boiler, 72 inches in diameter, with tubes 20 feet long? *Ans.* 24,000 common bricks are required for a flush front boiler, 72 inches in diameter, with tubes 18 feet long. The boiler in the example has tubes 2 feet longer than this. In the sixth column of the table we find that 860 bricks must be added for each lineal foot in excess of 18 feet, so to 24,000 we must add $2 \times 860 = 1,720$, giving 25,720 as the whole number of common bricks required. (The necessary number of fire-brick, 1,400, may be taken directly from the table.)

EXAMPLE 3. How many bricks will be required to set a battery of three boilers, side by side, each being 60 inches in diameter, with tubes 15 feet long, and with overhanging fronts? *Ans.* (1) The number of fire-brick required for one such boiler is 950, so that for three boilers we shall need $3 \times 950 = 2,850$ fire-brick. (2) The number of common brick needed for one boiler of this description, with tubes 16 feet long, is 18,200. The actual boiler is one foot shorter than this, so we deduct 760, which is the

NUMBER OF BRICKS IN BOILER SETTINGS.

Diameter of Boiler.	Length of Tubes.	Kind of Front.	Number of Common Brick.	Number of Fire Brick.	Additional Number of Brick per Foot of Length.	Number of Common Brick for each Boiler after the First.	Additional Number of Brick for each Boiler after the First, per Lineal Foot.
Inches.	Feet.						
36	10	Flush.	11,700	564	660	6,300	350
36	10	Overhanging.	11,000	525	660	5,900	350
42	12	Flush.	13,700	654	680	7,400	360
42	12	Overhanging.	13,000	629	680	7,000	360
48	15	Flush.	16,700	850	710	8,900	370
48	15	Overhanging.	16,000	816	710	8,500	370
54	15	Flush.	17,600	990	730	9,400	380
54	15	Overhanging.	16,700	886	730	8,900	380
60	16	Flush.	19,100	1,140	760	10,200	400
60	16	Overhanging.	18,200	950	760	9,700	400
66	16	Flush.	21,900	1,290	830	11,900	450
66	16	Overhanging.	20,600	1,080	830	11,300	450
72	18	Flush.	24,000	1,400	860	13,400	460
72	18	Overhanging.	23,000	1,150	860	12,800	460

number required, in a boiler of this description, for each additional foot in length. Hence, for the first boiler we shall need $18,200 - 760 = 17,440$ common brick. For each of the other boilers we should require 9,700 common bricks, if they had 16-foot tubes. As a matter of fact, their tubes are one foot shorter than this, so we deduct 400, (which is found in the last column of the table,) and we have 9,300 as the number of brick required for each of the two additional boilers. For both of them, therefore, we shall need $2 \times 9,300 = 18,600$ brick, which, in addition to the 17,440 required for the first boiler, gives 36,040 $(18,600 + 17,440 = 36,040)$, which is the whole number of common brick required for the battery.

THE builders of the naphtha launch *Ethel*, the wrecking of which was reported a short time ago in our regular monthly list of boiler explosions, write to say that the true story of the accident was as follows: "The owners of the *Ethel*, with two friends, and an oysterman whose seamanship is questionable, against the advice of experienced boatmen, went outside to fish, and attempted to return through Long Beach inlet against a strong ebb tide, with a brisk southeast wind blowing, across a bar on which there is but three feet of water at low tide. She was swamped in the breakers, her fire was put out, and, being thus rendered helpless, she capsized. The owner and his friends were drowned in attempting to swim ashore, while the oysterman was saved by clinging to a buoy. The launch was picked up afloat the next day, and was towed over the bar into the bay. On being righted, she proved to be perfectly whole and sound, except that her smokestack and retort were gone. The engine, tank, shaft, and steering geer were all in good condition."

The Mariner's Compass.

A writer in the *North China Herald* of Shanghai devotes a learned article to detailing and discussing the facts regarding the claim of the Chinese to have invented the mariner's compass. They did not learn the properties of the magnetized needle from any other country. They found it out themselves, though it is impossible to point to the man by name who first observed that a magnetized needle points north and south. He suggests that it came about in this way. The Chinese have in their country boundless tracts of ironstone, and among these no small portion is magnetic. Every woman needs a needle, and iron needles early took the place of the old stone needles, and were commonly used before the time of Ch'in Shihhuang — that is, more than twenty-one centuries ago. Whenever a needle happened to be made of magnetic iron, it might reveal its quality by falling into a cup of water, when it happened to be attached to a splinter of wood, for example. It came in some such way to be commonly known that certain needles had this quality. The great producing center for magnetic iron is T'szchon, in Southern Chihli. This city was very early called the City of Mercy, and the magnetic stone produced there came to be known as the stone of T'szchon, and so *t'szshih* became the ordinary name for a magnet. Later, the Chinese began to speak of the city as the "City of the Magnet," instead of calling it the "City of Mercy." The polarity of the magnetic needle would become known to the Chinese of that city and its neighborhood first. The first one to notice this polarity would be some intelligent person who communicated the fact as an unaccountable peculiarity in an age when omens and portents were diligently sought for in every natural object and phenomenon.

The earliest author who mentions the "south-pointing needle" lived in the fourth century B. C. There can be no reasonable doubt that the polarity of the needle was known at that time. The discovery of the fact must have preceded the invention of any myth embracing it. As to the discovery, there is no reason to suppose it was in any way foreign, because the Chinese use an enormous number of needles, and have an inexhaustible supply of ironstone. But, though the polarity was known, it was not turned to a practical use till the Tsin dynasty, when landscapes began to be studied by the professors of *fengshui* or geomancy. There was at that time a general belief in the magical powers of natural objects. This was a Buddhist doctrine, and it took firm hold on the Chinese mind of that age. The Chinese philosophers of those times taught that indications of good and ill luck are to be seen all through Nature. The polarity of the needle would take its place in this category of thought. Though it is not distinctly mentioned by writers of the fourth century, yet to their disciples it became an essential part of the landscape compass which the professors of *fengshui* all use. Kwo Pu, the founder of this system, died A. D. 324, and it was not till four centuries later that the *fengshui* compass began to assume its present form. The compass used by the professors of geomancy for marking landscape indications was first made about the eighth century A. D. It was of hard wood, about a foot wide, and it had in the center a small well, in which a magnetized needle floated on water. On the compass were inscribed several concentric circles, as on the wooden horizon of our globes. They embrace the twelve double hours, the ten denary symbols, eight diagrams, and other marks. This compass was used in preparing a geomantic report of any spot where a house or tomb was to be constructed, so that the construction might not be upon an unluckly site or planned in an unlucky manner. At the same time there was living a Chinese who had studied Hindoo astronomy, and was the imperial astronomer, and also a Buddhist priest. He noticed that the needle did not point exactly north, and that there was a variation of 2° 95′ [probably a misprint]. This variation went on increasing till a century later, — that is, till the ninth century. A professor of geomancy then added a new circle to the compass. On this improved compass the first of the twelve hours begins on the new circle at $7\frac{1}{2}°$ east of north.

The compass, it will be observed, grew out of the old astrological report or nativity paper, calculated from the position of the stars, and prepared in the Han dynasty by astrologers as a regular part of social life, especially when marriages were about to be solemnized. Some of the old astronomical circles are preserved in the new geomantic chart. This was the compass used when Shen-Kwa wrote on the south-pointing needle in the eleventh century. This author mentions that any iron needle acquires polarity by rubbing it on a piece of lodestone. He alludes to the variation as a fact which he himself had observed, and speaks of the south-pointing needle as an implement used by the professors of geomancy. By them it was employed in the form of a float upon water. After this, in 1122, an ambassador to Corea describes the use of the floating needle on board ship in which he made the voyage. This is the first instance, the earliest by more than a century, of the use of the mariner's compass on board ship, found as yet in any book, native or foreign. The existence of the book in which this is recorded settles the question of the first use of the mariner's compass at sea in favor of the Chinese. At that time the needle floated upon water, supported by a piece of wood, but in the Ming dynasty some Japanese junks engaged in piracy were captured by the Chinese, and the compass in use on board was found to have the needle dry and raised on a pivot, while still pointing southward. The Japanese had learned from the Portuguese navigators to make a compass of this kind, and probably the needles they used were brought from Europe. From this time, the Chinese adopted the principle of a pivot, and made their compasses without a well of water in the middle to float the needle in. Charts of a very rough kind were probably used, but how far is not known. What is known is that the junk-master was aware of the direction in which the needle must point to reach the port to which he was going. In the Sung dynasty, embracing part of the tenth, as well as the eleventh, twelfth, and part of the thirteenth centuries, Chinese junks went to Persia and India. The Arabs trading to China directly would learn at that time the use of the compass, and would apply it on board their dhows. From them the Europeans learned this useful invention.

The credit of the discovery, both of the polarity of a magnetized needle and of its suitability for use by mariners at sea, must, therefore, according to this writer, be given to the Chinese. It is China also that has the credit of having first noticed that any iron needle may be polarized by rubbing it with a magnet. In the thirteenth century the Arabs used a floating compass on their dhows. The needle was made to float on the water by attaching it crosswise to a cornstick or splinter of wood. A magnet applied to it drew it into a north and south direction. They would use Western notation to mark the quarters and intermediate points on the horizon. When, therefore, the mariner's compass was adopted from them, the Chinese twenty-four points were not communicated. In the European compass the notation of thirty-two points is Western, and rests on the winds and the sun. In the Chinese primitive mariner's compass the notation is that of the professors of geomancy, and rests on the old astrological division of the horizon into twelve double hours. From the Arab account we learn, what the Chinese accounts do not tell us, that the Chinese floated the needle by inserting it in a splinter of wood. — *Nature.*

The Locomotive.

HARTFORD, NOVEMBER 15, 1891.

J. M. Allen, *Editor.* A. D. Risteen, *Associate Editor.*

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Riveted Joints in Boilers.

In the July issue of the Locomotive we published in full the lecture of President J. M. Allen delivered at Sibley College, Cornell University, on the proportion and strength of riveted joints. This lecture has created deep and renewed interest in the whole subject, and the importance of understanding it thoroughly is impressed upon all boiler-makers and steam-users. The question may be asked, What has occasioned the special attention and importance given to this subject just at this time? Why has there been so little said, comparatively, in past years? The reply is: Formerly the pressures of steam used in boilers rarely exceeded 100 lbs. per square inch, the usual pressure being from 70 to 80 lbs. If boilers of exceptional high pressure were required, they were made of small diameter. Now not only high pressures are required, but also boilers of large diameter are called for. Formerly boilers of 54 and 60 inches in diameter were the sizes commonly used, and with pressures of from 75 to 90 lbs. per square inch they were safe if the material and workmanship were good. But the conditions have very materially changed. Boilers of 66 and 72 inches are now required, with pressures ranging from 110 to 150 lbs. The problem of a properly proportioned and constructed joint, therefore, becomes an important one.

Another question may be asked, What is the occasion of this demand for larger boilers and higher pressures? It is the introduction of improved steam engines known as the compound and triple expansion type; also the introduction of electric lighting which requires large steam room and high pressures. These large boilers and high pressures are, no doubt, all in the direction of economy for the steam-user. But in working for economy we must not lose sight of safety. In the riveted joints of boilers made ten or fifteen years ago, there was a large excess of rivet strength, but the strength of net section of plate, though much less than the rivet strength, was amply sufficient for the pressure used at that time. But under the conditions of to-day the former practice is not sufficient, and a radical change is imperative.

If we calculate the strength of some of the old double-riveted joints for which it was the custom to allow 70 per cent. of the strength of solid plate, we shall find that they often give not more than 60 per cent. This arises from the fact that the diameter and pitch of the rivets have not been carefully considered nor duly proportioned. We have had occasion to calculate the percentage of strength of triple-riveted joints which from their construction were no stronger than a well proportioned double-riveted joint. This defect arose from the fact that the rivets were not properly distributed. Other cases of comparatively weak joints that were intended for joints of excessive strength could be cited, but this is sufficient for this article. We are now making experiments and investigations on this subject, and hope at some time in the not very remote future to lay before our readers a fuller discussion of this whole subject.

A Collection of Fearful Curios.

Mr. McCormick, the London agent of the Chicago World's Fair, is negotiating for the loan or purchase of Lord Shrewsbury's famous collection of instruments of torture, formerly kept in the Royal Castle at Nuremberg. The collection which is now on view here is of a blood-curdling character calculated to astound gentle American citizens. There are between 700 and 800 pieces, — racks, tongue tearers, thumb screws, iron gloves, compulsorily worn red hot, barbed whips, strangling collars, spiked cradles, iron caps, an elegant array of executioners' swords, and a series of ancient prints illustrating executioners and methods of torture in the good old times, but the *pièce de résistance* of the show is the original iron maiden, which is thus accurately and unctuously described in the catalogue: "It is made in the shape of a woman, a Madonna, before which the victim was compelled to kneel in prayer. It opens with two doors to admit the victim, and inside is fitted with sharp iron spikes, so arranged that when the doors are pressed to, these sharp prongs force their way into various portions of the victim's body. Two entered his eyes, others pierced his back, chest, and, in fact, impaled him alive in such a manner that he lingered in most agonizing torture, when death relieved the poor wretch from his agonies, perhaps after days. Then the trap door in the base was pulled open, and his body was allowed to fall into the moat or river below." — *New York Sun.*

A Terrible Accident.

A few days ago Mr. James E. Graves of East Boston was brought into the city hospital in a frightful condition. He was an employe of the Standard Stave Cooperage Company, says the *Boston Globe*, on Chelsea street, East Boston, and his duty carried him often into the steam room where barrel staves are seasoned. The other morning at 10 o'clock he entered the room and left the door ajar, so that he might make his exit readily. While he was there, another workman entered, and left again before Graves had completed his work; and in going out, he thoughtlessly closed the door behind him. When Graves tried to leave the room, which by that time was clouded with hot steam, which had been turned on, full force, he found that the door resisted his most strenuous efforts to get it open, and the appalling prospect of death in the hot box confronted him. He may have screamed and banged on the door; but if he did, it was to no purpose. No one heard him, and when overcome by the scorching vapors, he sank to the floor exhausted, where he was found, a short time afterwards, by another employe, Nelson Smith, who had occasion to visit the room on business. He was taken out in an unconscious and almost lifeless condition, and conveyed to the hospital, where he died in great agony a few hours later. For fifteen minutes, and perhaps longer, he lay upon the floor of the steam box and was subjected to the full heat of the life-destroying steam, and he had breathed it in until his lungs were raw, and his internal organs had suffered as much as the surface of his body.

This accident calls attention once more to the dangers to which our inspectors are sometimes exposed. It is often necessary for them to enter a boiler when other boilers in the same battery are running as usual. Under these circumstances the stop-valve on the idle boiler is the only thing that stands between him and death. In thousands of cases our inspectors have made inspections in this way, and in nearly every case there has been no trouble. It has happened on some occasions, however, that some person has started to open the stop-valve, either mistaking it for some other valve, or not knowing that any one was inside. In all the cases of this kind that have yet happened, the inspector has been able to get out of the boiler in time, though in one or two instances he has had a close call. We would direct special attention to this matter, because there is no need of any trouble, if a little care is taken. It is a safe rule not to open or close *any* valve while the inspector is in the boiler; and the engineer or fireman should see to it that no person does so.

Curious Accidental Cures.

A gentleman was suffering from an ulcerated sore throat, which finally become so swollen that his life was despaired of. When his household came to his bedside to bid him farewell, each person grasped his hand for a moment and then turning went out weeping. A pet ape, which had modestly waited till the last, then advanced and grasped his master's hand for a minute, also turned and went away with his hands to his eyes. This assumption of deep grief, which it is hardly possible the animal could have really felt, was so ludicrous in its perfection that the sick man was seized with an uncontrollable fit of laughter which broke the ulcer in his throat, whereby his life was saved.

The great Erasmus laughed so violently while reading the Epistolæ Obscurorum Vilorum (letters of obscure men against the monks) that he broke an imposthume and saved his life.

A somewhat similar story is related of the celebrated grammarian, Urbain Domergue, who had an abscess on his throat, which broke in a fit of passion with which he fell on his physician for committing a solecism in grammar.

Rev. George Harvest, rector of Thames Ditton, England, was very absent-minded, so that on one occasion he went into a friend's house, and, seeing no servant, he rambled over it, finally entering the room of an old lady, ill of quinsy. He stumbled over a clothes-horse, and in his awkwardness made the patient burst into such a fit of laughter that the quinsy broke, and she lived many years to thank him. — *American Notes and Queries.*

The Liquefaction of Gases.

Steam and many other vapors are readily converted into a liquid form by the application of cold, and the idea long ago occurred to physicists that what we usually call the "permanent gases," such as oxygen, hydrogen, and carbonic acid gas, as really the vapors of liquids that have exceeding low boiling points, and it was believed that they also could be liquefied if a sufficient degree of cold could be brought to bear upon them. Some of them, as, for instance, the fumes of burning sulphur, condense by the application of a very moderate degree of cold, while others resisted the lowest temperatures that could be produced by the means the experimenters could command. The effect of great pressure was also tried, for it was known that pressure raises the boiling point of water, or, what is the same thing, it raises the condensing point of steam; and reasoning from analogy, it was considered probable that pressure would raise the condensing points of other gases and vapors, so as to bring them up within the range of temperature that can be commanded in our laboratories. Many gases succumbed to the combined influence of great pressures and low temperatures, but oxygen, hydrogen, nitrogen, and a few others still resisted. The researches of Dr. Andrews have thrown much light on this subject, and given us a clear understanding of the circumstances under which a gas may be liquefied; so that now all the gases we are familiar with have been liquefied, and some have been solidified. Carbonic acid gas, for example, has been produced in the solid form, and we believe that somebody in England is selling it in bricks. At any rate it forms a white solid that can be hammered, and which is heavy enough to sink in water.

Dr. Andrews has proved that there is a certain "critical" temperature for every gas, at which the gas can just be liquefied by pressure, but above which no amount of pressure can liquefy it. The pressure that will just liquefy a gas that is at this critical temperature is called the "critical pressure"; and the volume occupied by a liquid that is at its critical temperature and pressure is called the "critical volume." A few of the best determined critical points are given in the table below. The temperatures are in centigrade degrees, the pressures are in atmospheres, and the volumes are expressed as fractions of the volumes occupied by the respective gases at 15° C. and one atmosphere pressure.

TABLE OF CRITICAL POINTS OF GASES.

Substance.	Critical Temperature.	Critical Pressure. Atmospheres.)	Critical Volume.	Authority.
Steam,	412° C.	?	?	Maxwell (observed).
"	434°	378	—	" (calculated).
Carbonic acid gas,	30.92°	75	?	"
Ether,	190°	36.9	.01733	Ostwald.
Bisulphide of Carbon,	272°	74.7	.01015	"
Sulphur dioxide,*	155°	78.9	.00744	"
Alcohol,	234°	62.1	.01112	"
Ethyl chloride,	183°	52.6	.01190	"
Benzine,	281°	49.5	.01534	"
Acetone,	233°	52.2	.01329	"
Ethyl acetate,	240°	42.6	.01654	"
Chloroform,	260°	54.0	.01333	"
Ethyl formiate,	230°	48.7	.01429	"
Methyl acetate,	230°	57.6	.01198	"
Diethylamine,	220°	38.7	.01744	"
Nitrous oxide,†	36.40°	37.1	.00582	"

* The fumes given off by burning sulphur.

† Laughing gas.

The critical points for oxygen, hydrogen, and other gases that have been liquefied with great difficulty, are not given in the table, because they have not yet been satisfactorily determined.

There is one important and curious thing that follows from the fact that gases have critical temperatures. If we heat a cubic foot of carbonic acid gas up to 50° C., for example, we can then compress it all we please without producing the least sign of liquefaction, because its critical point is 30.92°, and it cannot be liquefied at any temperature higher than 30.92°. Let us now compress it until its pressure is, say, 150 atmospheres. It is still a gas, because its temperature is above the critical point. Finally, we cool the gas, still under the pressure of 150 atmospheres, to say, 15° C. "During this process," as Maxwell says, "no sudden change of state can be observed, but carbonic acid gas at 15° C. and under a pressure of 100 atmospheres, has all the properties of a liquid. At the temperature of 15° C. we cannot convert carbonic acid gas into a liquid without a sudden condensation; but by this process, in which the pressure is applied at a high temperature, we have caused the substance to pass from an undoubtedly gaseous to an undoubtedly liquid state without at any time undergoing an abrupt change similar to ordinary liquefaction." This experiment shows that the liquid and gaseous states of a body are not so different from each other as has been popularly supposed, but that a body may be made to pass from one state into the other in a continuous manner, and without any abrupt change."

The Projected Pacific Cable.

The following account of the work done by the *Tuscarora* and about to be undertaken by the *Albatross*, from the San Francisco *Evening Bulletin*, was sent to THE LOCOMOTIVE by Mr. J. B. Warner, chief inspector in our Pacific coast department. It will doubtless be of interest to our readers:

"The steamer *Albatross* is expected to come down from Mare Island some time during the next fortnight, and make ready for a slow cruise to Honolulu. In response to demands, frequent and urgent, the Secretary of the Navy recently detailed this vessel to make desired soundings for the prospective cable between this port and the Hawaiian islands. Captain Z L. Tanner, the commander, will have general charge of the work. As he is a fish enthusiast and expert, and the *Albatross* is regularly set apart for the work required by the United States Fish Commissioner, the cruise will likely result in more of value than simply details relating to measurement of ocean depths and the color of mud that may be fished up by the dredger or sounding-wire caissons.

"The *Albatross*, since she came to this coast over two years ago, has accomplished

Fathoms.	Ocean Bottom.	Fathoms.	Ocean Bottom.
435	Mud.	2,908	Brown ooze.
850	Green ooze.	2,436	Brown ooze.
1,060	No specimen.	2,547	Brown ooze.
2,045	Green ooze.	2,597	Brown ooze.
2,041	Blue mud.	2,481	Brown ooze.
2,399	Blue and yellow mud.	2,652	Brown ooze.
2,529	Yellow-brown mud.	2,682	Brown ooze.
2,543	Yellow ooze.	2,684	Brown ooze.
2,571	Yellow-brown ooze.	2,759	Brown ooze.
2,538	Yellow-brown ooze.	2,724	Brown ooze.
2 630	Brown ooze.	2,652	Brown ooze.
2,576	Yellow-brown ooze.	2,625	Light-brown ooze.
2,688	Brown ooze.	2,685	Brown ooze.
2,742	Brown mud.	2,657	Brown ooze.
2,746	Brown mud.	2,694	Light-brown ooze.
3,252	No specimen.	2,821	Yellow-brown ooze.
2,716	Brown ooze.	2,794	Brown ooze.
2,561	Brown mud.	2,884	Brown ooze and lava.
1,407	Coral and lime.	2,904	Yellowish-brown ooze.
435	Coral.	2,950	Brown ooze.
413	Rock.	2,882	Brown ooze.
975	Rock.	2,893	Light-brown ooze.
404	Hard rock.	2,941	Brown ooze.
1,481	White mud and sand.	2,934	Brown ooze.
2,282	Brown ooze.	2,910	Brown ooze.
2,288	Brown mud.	2,994	Yellow ooze.
2,177	Brown mud.	3,115	Brown ooze.
2,471	Brown mud.	2,617	Brown ooze.
2,700	Brown mud.	2,443	Brown ooze.
2,537	Brown ooze.	2,464	Sand.
2,534	Brown ooze.	2,685	Sand and mud.

much in the field of marine science. She has been off the Alaskan coast, the Puget Sound district, and the coast of Lower California. In making soundings on the proposed cable route there is new territory, the investigation of which will doubtless show many interesting features of marine life. C. H. Townsend, the naturalist of the steamer, joined her yesterday. He has been doing some special work in Puget Sound. Mr. Alexander, who has been engaged as the expert fisherman of the vessel, is still with her. Captain Tanner, as commander, will direct all operations, but Mr. Townsend will have entire charge of all fish, shells, and marine flora of which specimens may be obtained.

"The work will probably take between one and two months. It took Commander Henry Erben, who was on the *Tuscarora* in 1874, just a month to make a similar reconnoissance, as this experimental sounding work may be termed. In the 2,100 miles distance between here and Honolulu he made sixty-two soundings, an average of one every thirty-four miles. His line, the published charts of the Coast Survey show, was as direct a one between the Farallones and Honolulu as could well be made by any vessel. The supposition is, therefore, that the *Albatross* will follow the Tuscarora line very closely. Through the courtesy of Professor Davidson of the Coast Survey the complete record of these soundings is here given, showing the depths at intervals from the Farallones, and the character of the bottom as indicated in the same samples brought to the surface. As this report, giving the record, is now exhausted among department publications, the publication here should prove of value to those interested in this cable project.

"An examination of these soundings show that the ocean bottom between here and the Hawaiian Islands is comparatively flat, with uniformly soft mud or ooze for its upper crust, upon which a cable could easily and safely rest. This vast ocean plain is at an average depth of 2,600 fathoms, or between three and four miles. Only once is it broken on the route surveyed by the *Tuscarora*. That was at a point about 650 miles southwesterly from this port where a depth of only 413 fathoms was found. This is the crest of a submarine mountain, but soundings show its sides are no steeper than those of Mount Diablo, and a cable might rest upon it. Doubtless the *Albatross* people will endeavor to find a point north or south of this, where the general even contour of the ocean bottom is not interrupted. Rear Admiral Belknap, when in the *Tuscarora*, in 1874, also reported finding the crest of this mountain, and in his honor it was christened Mount Belknap. He was then engaged in sounding for a line between San Diego and Honolulu, and his line crossed that of the line from this port to Honolulu.

"A curious occurrence, resulting in the loss of a steamer, occurred recently off the Varanger Fiord in the north of Norway," says Beyer's *Weekly News*. "A whale that had been harpooned by one of the steamers employed in those waters turned upon its pursuers and rammed the vessel, holing it so badly that it sank almost immediately, the crew having just time to escape from the sinking ship in boats. The whales of the species frequenting the seas of the north coast, from North Cape eastward to Varanger Fiord, are notoriously vicious when attacked, and if not killed at once by the explosion of the shell attached to the harpoon are apt to be dangerous.

"We recollect a somewhat similar incident that happened eighteen years ago. A whale was struck, but not killed immediately, and it rushed off, towing the vessel after it by the harpoon line at a great speed. The engine of the steamer, about thirty horse power, was started at full speed astern to counteract the whale's strength, in the expectation that the animal would soon succumb, but without avail; then the sails were hoisted and backed, to still further increase the drag, but still the vessel continued to be towed at a high speed, on a direct north course, away from the coast. The vessel was towed in this way for nearly fifty miles without any sign of the animal giving in. At length the position became so critical, the vessel not being provided with an outfit for reaching the north pole, that the tow-rope was cut, and the whale allowed to escape." [!]

Incorporated 1866.

Charter Perpetual.

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The Locomotive.

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Contaminated Water.

The necessity of having pure water for drinking purposes is now universally admitted, and great care is taken to insure the purity of the supply, especially in cities where the problem is more difficult than in the country. The same care is not always taken to insure purity in the supply used for boilers, and the result is that repairs and delays often result, which are always annoying and often expensive. It frequently happens that a source of water that was sufficiently pure at the outset becomes contaminated in the course of time by the gradual and progressive accumulation of sewage and other organic matter in the soil through which the supply comes. This is particularly true of wells. The trouble that such organic impurities may give rise to is shown by the cuts in the present issue, which illustrate some of the many cases of this kind that we meet with in our work of inspection.

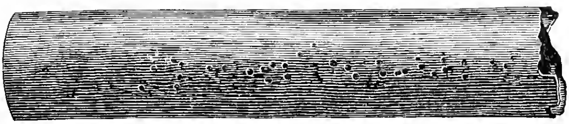

FIG. 1. — A PITTED TUBE.

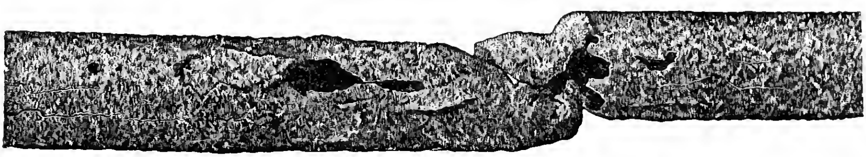

FIG. 2. — TUBE CORRODED BY CONTAMINATED WATER.

Fig. 1 represents a portion of a tube that was taken out after three weeks' use. The boiler from which it was taken had some scale on both tubes and shell, but not enough to give trouble. The feed water was taken from the city service, and was supposed to be the same as that used for domestic and general purposes. The trouble in this instance first showed itself by the leaking of the tubes; and on removing the leaky tubes to put in new ones it was found that they were badly pitted, although no evidence of pitting had been seen at the inspection some eight months before. The tube shown in Fig. 1 was one of the new ones, and, as has already been said, it failed in about three weeks, and others that were put in at the same time failed within a month. The trouble was evidently with the water, the new tubes giving out more quickly than the old ones, because the scale on the old ones protected them to a considerable extent. It could not have been with the quality of the tubes, as three different makes were tried. Upon investigation it was found that well-water was used about the establishment for mechanical purposes, and upon tracing out the pipes it was further found that the city service pipes and the pipes from the well were connected. The valves on the connecting pipe were supposed to be closed, however, the connection having been made so that feed water could be obtained from the well in case of an emergency, such, for example, as the temporary shutting off of the city service. It was then discovered that on account of the failure of a valve the water pumped from the well found its way into the receiving tank from which the boilers were supplied. The pipes to the well were then disconnected entirely, and the trouble ceased. The vicinity of this well had been used as a dumping ground for general débris, and it also received drainage from the cesspools of adjacent buildings. It appeared to be somewhat affected, too, by a neighboring salt marsh.

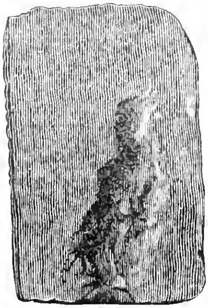

Fig. 3.—A Corroded Plate.

The tube twisted and torn in removal (Fig. 2) was taken from a boiler that had been in use six months in a creamery. All the tubes were in much the same condition as that shown in the cut. The cause of the trouble was very evident in this case, as the feed-water was taken from a well into which the drippings from the creamery percolated.

A good illustration of the progressive contamination of water is offered by the boiler from which the pieces shown in Figs. 3 and 4 were taken. Fig. 3 shows the first observed evidence of an attack on the shell, though during the previous year the tubes had shown signs of failure, and several had been taken out. For the first four or five years, however, the boiler had shown no deterioration, though some scale was deposited in it; but as the soil through which the water supply came to the well became more thoroughly saturated with organic impurities, the corrosive action became more severe. The piece shown in Fig. 3 was cut out, together with a portion of the adjoining plate that was also affected, and a patch was put on. Fig. 4 shows one-half of this patch after it had been in use one year. The water had grown continually worse, and deterioration pro-

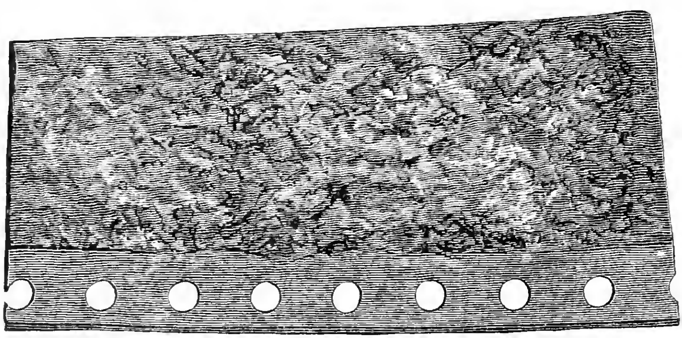

Fig. 5.—A Badly Corroded Steel Plate.

gressed most rapidly, especially on the new plate, which was unprotected by scale. The water supply was changed, when the condition of the patch became known, and the destructive action ceased.

Fig. 5 shows a section taken from a steel boiler that had been in use only two years. A lime scale formed on the plates and tubes, and gradually settled down on the plates as a sludge. Although the coating so formed was not thick or hard, the salts of which it was composed were active in producing corrosion, and the whole bottom of the boiler was destroyed. The feed-water was taken from a well, and it had been in use for many

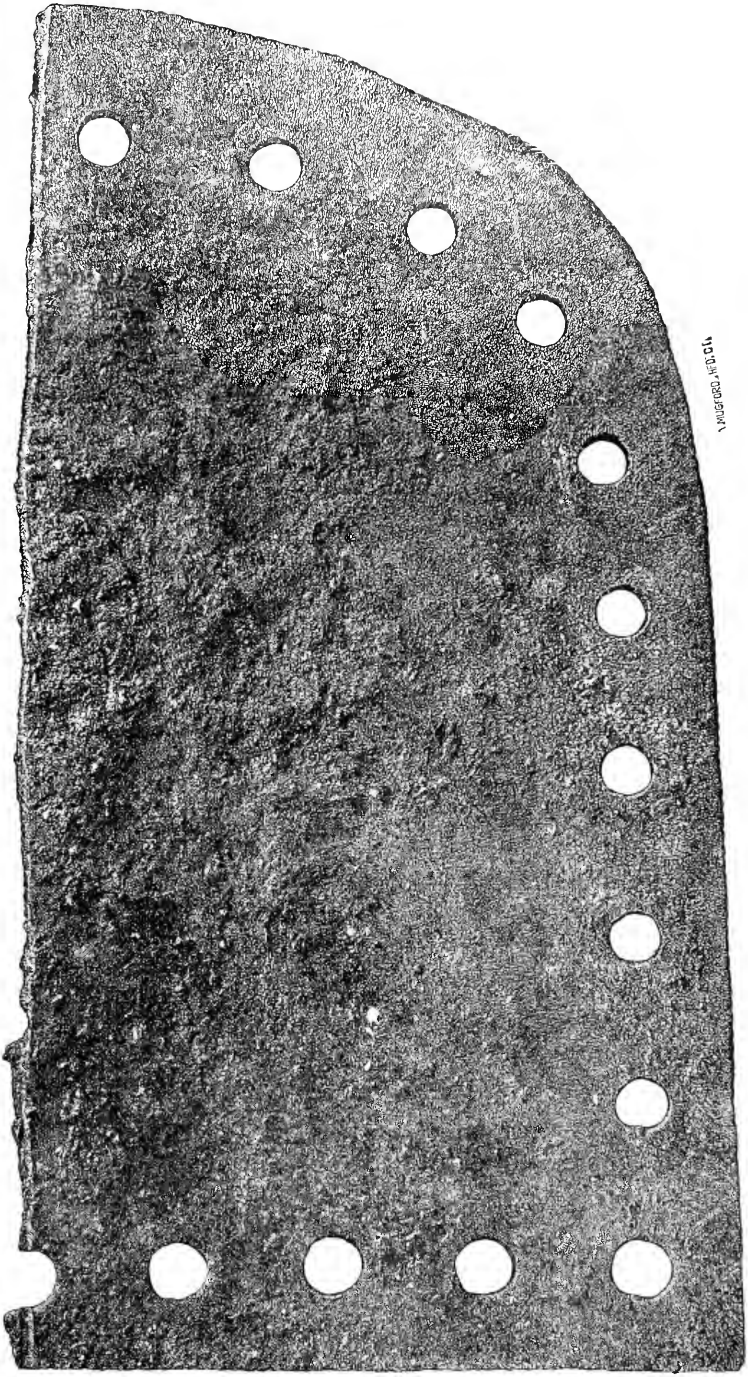

Fig. 4. — Showing the Corrosion of a Patch in use One Year.

years without showing any corrosive action. The older boilers in the battery had been protected from the water to a considerable extent by scale, though subsequent examination of them showed a slight indication of the same trouble on some of the plates. By the time the new boiler was put in the water had become so impregnated with the impurities in the soil that the clean surface of metal was attacked vigorously.

Fig. 6 shows a case of grooving along a joint, arising from the same cause. The entire lower half of this boiler was destroyed. The feed-water was taken from a well, which had formerly furnished the best of water, since it had a rock bottom and was fed directly by a spring. It was definitely known that the shell was free from pitting and corrosion on a certain date, the tubes having been removed for examination. The same

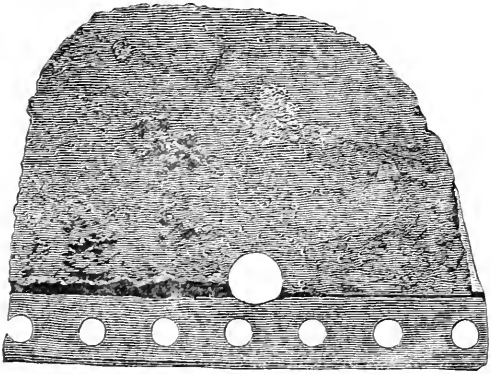

FIG. 6. — A GROOVED AND PITTED PLATE.

year a sewer was built in the neighborhood and the spring that had supplied the well was cut off, so that surface drainage had to be relied upon thereafter. The result was that the new supply, percolating through soil already saturated by outhouses and cesspools, was of so different a character that it was not only unfit to use, but positively dangerous.

A great many other examples of the action of contaminated water could be given, as we meet with them continually in our practice. No certain rule for avoiding its dangers can be given. The safest thing that can be done is to watch the boilers carefully, and if signs of trouble are perceived, a purer supply of water should be secured. An apparently slight source of contamination may give rise to serious trouble, especially in new boilers. The carbonate of ammonia produced by the fermentation of urea in outhouses is particularly destructive, and care should be taken to keep feed-water from being contaminated with it.

Inspectors' Reports.

SEPTEMBER, 1891.

During this month our inspectors made 5,726 inspection trips, visited 10,891 boilers, inspected 5,177 both internally and externally, and subjected 603 to hydrostatic pressure. The whole number of defects reported reached 8,890, of which 822 were considered dangerous; 33 boilers were regarded unsafe for further use. Our usual summary is given below :

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	746	38
Cases of incrustation and scale,	1,393	58
Cases of internal grooving,	66	9
Cases of internal corrosion,	360	14
Cases of external corrosion,	673	39
Broken and loose braces and stays,	99	46
Settings defective,	226	37
Furnaces out of shape,	223	30
Fractured plates,	137	34
Burned plates,	207	26
Blistered plates,	286	8
Cases of defective riveting,	1,659	64
Defective heads,	76	25
Serious leakage around tube ends,	1,509	270
Serious leakage at seams,	401	17
Defective water-gauges,	147	29
Defective blow-offs,	95	17
Cases of deficiency of water,	14	7
Safety-valves overloaded,	45	7
Safety-valves defective in construction,	47	19
Pressure-gauges defective,	371	21
Boilers without pressure-gauges,	3	3
Unclassified defects,	107	4
Total,	8,890	822

Boiler Explosions.

October, 1891.

Rolling Mill (178). On October 1st, the north boiler in the plate mill of the Cleveland Rolling Mill Company, Cleveland, O., exploded with great violence. The boiler was one of a battery of two. The setting and stack were blown down, and the other boiler was blown from its setting. Six boys were working in the mill at the time, and three of them were scalded and otherwise injured. The property loss is estimated at $4,000.

Evaporating Works (179). The boiler in the Evaporating Works, at Eaton Rapids, Mich., exploded, on Oct. 2d, with terrific force, waking up the city. The building was torn to pieces, and huge portions were thrown several hundred feet away. When the confusion had subsided somewhat, the body of E. S. Bromeling, foreman of the works, was found. He was dead and badly mangled. The loss is estimated at from $8,000 to $10,000.

Traction Engine (180). On Oct. 3d, a south-bound passenger train on the C. H. & D. road collided, near Dayton, O., with a traction engine which a farmer was taking from one side of the track to the other, and which had become stalled in the middle of the track. At the moment of the collision the boiler of the traction engine exploded with terrible force, but the train escaped with comparatively slight injuries.

STONE CRUSHER (181). The engine connected with the stone-crusher at Oakalla, four miles west of Green Castle, Ind., exploded on Oct. 3d, just as the workmen had finished their week's labor. The engineer, James Howell, was killed, and another employe named Abel sustained injuries that may result fatally.

TUG BOAT (182). A boiler exploded on board the steam tug *C. W. Parker*, in Chicago, killed seven persons, and seriously wounded eight others, on Oct. 4th. The tug, in company with three others, was engaged in attempting to tow the coal steamer *H. S. Pickands* out of the draw of the Archer avenue bridge in the south branch of the Chicago river. Three of the killed were employes of the tug. Their bodies have not yet been recovered. The other persons killed were standing on the banks of the river, to which a number of spectators had been drawn to witness the removal of the steamer, which arrived on Saturday from Buffalo with a cargo of coal. The vessel had run aground in the draw, and the four tugs were putting forth every effort to move it, when the *Parker* exploded.

MINE (183). Wm. Mittolstadt, a fireman at the Ashland mine, Ironwood, Mich., died Oct. 12th, from injuries received through the bursting of a blow-pipe on the boiler, the hot water and escaping steam scalding him before he could escape.

STEEL WORKS (184). Park Brothers' Black Diamond Steel Works, at Thirtieth and Smallman streets, Pittsburgh, Pa., was the scene of a terrific explosion on Oct. 12th. A large "triple" valve on the main steam pipe gave way, scattering huge pieces of boiler plate and debris in all directions. F. C. Ebling, an employe, was fatally crushed, and several other employes were badly hurt, and sixteen hundred men were thrown out of employment until necessary repairs could be made.

STRAW-BOARD WORKS (185). On Oct. 12th, one of the boilers of the American Straw-board Company, in Anderson, Ind., gave way. The explosion shook all the north part of the city, and the escaping steam attracted a large crowd to the factory. Fortunately none were injured. This plant has twelve of the largest boilers in the city. The engineer and an assistant narrowly escaped being scalded by steam. The damage to the building was slight, and was easily repaired.

ELECTRIC LIGHT PLANT (186). The boiler of the Bessemer electric light plant, in Bessemer, near Birmingham, Ala., exploded on Oct. 12th, completely wrecking the boiler-house, and doing damage to the amount of about $2,000. No person was hurt. The burst boiler was raised high in the air, and timbers of the boiler-house were blown a great distance.

CIDER MILL (187). The boiler in Sanderson's cider mill, in Shelby, near Medina, N. Y., exploded on Oct. 13th. No one was seriously injured, though several were bruised. The boiler, engine, and building were completely wrecked.

HEADING FACTORY (188). A terrific boiler explosion occurred in Tipton, Ind., on Oct. 13th. The large heading factory of A. R. Coleman, which gives employment to about fifty hands, was reduced to a mass of ruins by the explosion of a large seventy-five horse-power boiler. The engineer, John M. Weir, who was sitting in front of the boiler, was covered by the debris and severely injured, and six or seven other persons were more or less bruised. Mr. Coleman's loss is said to aggregate about $15,000.

MAIL STEAMER (189). The boiler of the mail and passenger steamer *Evangel*, running between Port Townsend and Bellingham Bay, exploded at the Sehome dock, New Whatcom, Wash., on Oct. 14th. Gus Carlson and William Biggs, deck hands, and Julius Flint, fireman, have died from injuries received. Alfred Riggs, second engineer, was severely scalded. John Feeney, fireman, Job Burrows, cook, and Chas. Turner, steward, both colored, were badly burned, and David Ross, a fireman, had his skull fractured. All the injured are at the Marine Hospital, where they were brought in the morning. Several of the injured are likely to die. The steamer was insured for $7,500, but this is insurance against fire or marine disaster. Captain Morgan places his pecuniary loss at $10,000. The boiler tore its way from the bottom of the hold, carrying everything away forward and above. The hull is not injured, but the water tank was cracked, partly filling the vessel with water. The *Evangel* has quite a history, she having received her name from the object for which she was built. The vessel was intended for a missionary boat, and was built ten years ago by the pennies of Eastern Sunday-school children. The project was undertaken by a missionary society, and collections were taken throughout the East for the purpose of raising funds. It was the intention to keep her in the mission field among the then sparsely settled districts of Puget Sound. She did not continue in this work long, but was soon chartered as a freight boat. At one time she secured the contract to carry the mail to Alaska. A rival company, however, succeeded in getting her tied up, so she missed a trip and forfeited her contract. For the past three years she has been owned by Morgan & Mann of Port Townsend, who now have the contract for carrying mail through the islands between Port Townsend and Bellingham Bay. She was valued at $15,000.

Locomotive (190). On Oct. 14th, at South Park, St. Paul, Minn., ten men were injured, two probably fatally, by the explosion of a locomotive boiler in the Kansas City railway shops. A gang of machinists were working on the engine, getting it ready for use, when the explosion occurred. The doors of the shop were torn down, and the men thrown in every direction.

Cotton Mill (191). On Oct. 15th, a ten-horse portable boiler, belonging to Mr. George Baker, which was being used in the Lowell cider mill, at Middlebury, Pa., exploded with terrific force. The shattered boiler was thrown a distance of 150 feet. The report was tremendous, and was heard for miles. Mr. Baker was the only person near the boiler when it gave way, and was the only one injured. A piece of iron struck him and broke his left shoulder.

Flouring Mills (192). The boiler in the flouring mill at Doolittle Mills, at Columbus, Ind., exploded on Oct. 15th, when the engineer and fireman were at supper, and Mayfield Snyder was seriously scalded.

Cotton Gin (193). Tom Black, engineer at Scales' gin, near Paris, Tex., was killed, on Oct. 17th, by the explosion of the boiler. He was scalded badly.

Saw-mill (194). At Clarksburg, near Jackson, Miss., on Oct. 17th, a saw-mill boiler exploded, killing Sam Harold and Ephraim Ely, and mortally wounding Allen Lindsley.

Locomotive (195). On Oct. 19th, a terrible accident occurred at Tucker's Watch-Box, a short distance below St. Clair, near Pottsville, Pa., in which three men were killed, and one fatally injured. Mountain Engine 995, on the Philadelphia & Reading road, was drawing a train of empty cars up the grade when the boiler exploded, completely demolishing the engine, tearing up the tracks, and doing great damage to telegraph lines and surroundings. The names of the killed are Chas. Warnicker, brakeman, of St. Clair; Harry Wagner, engineer, of Port Carbon; Mahlon Keese, fireman. Chas. Baur, brakeman, of St. Clair, is fatally injured. The men were in the cab when the explosion took place. No cause is assigned for the explosion, the engine being just out of the shops.

MACHINE WORKS (196). The boiler of the Brookhaven Machine Company, Brookhaven, Miss., exploded on Oct. 20th, instantly killing James Hoskins, fireman, and wounding C. A. Woodbury.

BREWERY (197). The Raritan brewery, owned by Joseph Schneider, at Highland Park, N. J., was burned at daylight on Oct. 20th, entailing a loss of $75,000, on which there is an insurance of $28,000. Schneider and his family occupied an adjoining dwelling, and narrowly escaped with their lives. One of the boilers exploded during the progress of the fire, blowing out the walls of the engine-room.

SAW-MILL (198). Early on the morning of Oct. 21st, before work had begun at the Stillwater Lumber Company's mill, at South Stillwater, near St. Paul, Minn., one of the boilers burst, owing to a defect in the metal. No one was injured, and very little damage was done. Had the accident occurred an hour later, it would undoubtedly have caused more serious results.

LOCOMOTIVE (199). A serious accident occurred on the Iron Mountain road, near Little Rock, Ark., on Oct. 21st. The boiler of a locomotive drawing a freight train exploded, while the train was in motion. The engineer escaped with slight burns, but the fireman and a brakeman are said to have been fatally injured. The locomotive was almost demolished, and the track was torn from the ties for some distance.

THRESHING MACHINE (200). Six men were killed, near Mayville, N. D., on Oct. 22d, by the explosion of the boiler of a threshing machine.

SAW-MILL (201). A boiler at John Quigley's saw-mill, Glasson, Ky., exploded on Oct. 24th, killing a child named Morton, and fatally injuring two other children and Mr. Quigley. Three men employed about the mill were badly hurt.

ELECTRIC LIGHT PLANT (202). As the result of a boiler explosion in the heart of the city of Louisville, Ky., on Oct. 26th, one man was killed, several persons were painfully injured, and nearly half a million dollars' worth of property was destroyed. The boiler was in the electric light plant of the Louisville Gas Company. Fireman Adams, who was in the boiler-room, was fatally injured. A mass of iron and hot coals were thrown across the alley into the rear of Kaufman & Strauss's large dry goods store. Half a dozen clerks who were in the rear of the store were painfully injured, and in a moment the whole building was in flames. The fire department was quickly at work, and by the most strenuous efforts succeeded in saving the *Courier-Journal* building immediately north and the Polytechnic Library on the south, although the library building was considerably damaged. The stores of Escott & Sons, Leverone, and Porter were also badly damaged.

PORTABLE SAW-MILL (203). The boiler of a portable engine exploded on Oct. 29th, on a farm occupied by Mrs. Ellen Howard, about one mile from Frederick, Md. It was noon, and nobody was near; but the engine was completely wrecked.

AN explosion, the precise nature of which we have not learned, occurred on the United States steamship *Atlanta*, on or about Oct. 13th, by which six men were injured,— two of them dangerously.

FOLLOWING is the list of non-resident lecturers at Cornell University for 1891–2, for which we are indebted to *The Crank:* Eckley B. Coxe, Oct. 23; C. J. H. Woodbury, Nov. 6; F. W. Clarke, Nov. 13; Lieut.-Col. W. R. King, U. S. A., Dec. 3; R. P. Rothwell, Jan. 7; C. E. Emery, Jan. 21; Capt. Henry Metcalf, U. S. A., Feb. 11; Capt. E. W. Hunt, Feb. 25; E. D. Leavitt, March 10; George H. Babcock, April 14; J. M. Allen, April 28; J. H. Holloway, May 5; Alexander Graham Bell, May 26. A number of other gentlemen, whose dates are not yet determined, will also deliver lectures. Among these are E. F. Fenallosa, of the Boston Fine Art Museum, Professor Anthony, W. J. Hamner, C. B. Dudley, Dr. L. Gatling, and a number of distinguished electricians, naval engineers, architects, and other officers and engineers in a variety of special lines of professional practice.

Wedged into his Boiler.

The following account of a rather unusual accident is taken from a New York daily paper:

Daniel Donlin, engineer of the Colonnade Hotel in Broadway, was caught in the boiler in his engine-room a few days ago, and wedged in so tightly that he was unable to move hand or foot. He remained in this position for two hours before help came to him, and when help did come it was found necessary to take the boiler apart in order that he might be extricated. The Colonnade Hotel runs through the block to Lafayette Place, and Judge Hilton is its owner. Back in Lafayette Place is the engine-room in which is the boiler that heats the hotel building. About 9 o'clock A. M., Donlin, the engineer, started to clean the boiler. He climbed into the manhole in the dome of the boiler and lowered himself down. The dome of the boiler rests on top of the shell, and the opening in the boiler itself is somewhat smaller than the man-hole in the drum. In some way Donlin got his knees wedged and found himself almost unable to move. He tried to get out, and the more he labored the worse his situation became, until finally he could not move up or down. Only his head and shoulders were visible above the boiler. He called for help, and some of the hotel employes responded. They tried to pull him out, but they couldn't make him budge. The manager of the hotel was informed of the situation, and policeman Gannon of Mercer Street station was called. The latter sent for an ambulance. It came with surgeon Charles Weeks, and Judge Hilton. who had been telegraphed for, hurried down to the hotel. He sent for a gang of boiler men, who came down from their shop in West 34th Street, loaded with tools. Donlin was getting weak, and surgeon Weeks gave him small doses of brandy to drink and ammonia to inhale to keep him up. The heat in the engine-room and the excitement over the situation had the effect of exhausting the wedged-in man. The ambulance doctor was constantly at his side, however, administering stimulants, so he was kept alive, and Judge Hilton gave orders to do everything possible. After a careful examination the boiler-makers decided that in order to release Donlin the boiler would have to be taken apart, and the work was begun. It was a tedious task taking out the many rivets which held the dome of the boiler. but the men worked with a will, and finally all the rivets were removed and the dome of the boiler was lifted off. It was then found that Donlin could not be released until one of the side plates had been forced out. The men went to work again, and it was 11.30 o'clock when the side of the boiler was cut open and the engineer lifted out. His legs had slipped down from the manhole of the dome inside the boiler, and his feet had been caught in between the steam-pipes. When taken out he was very weak and exhausted, and he was removed to St. Vincent's Hospital. He sustained no serious injury, and is now fully recovered from the effects of his experience.

The Locomotive.

HARTFORD, DECEMBER 15, 1891.

J. M. ALLEN, *Editor.* A. D. RISTEEN, *Associate Editor.*

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INDEXES and title-pages for Volume XII of THE LOCOMOTIVE may now be had by those who wish them, by applying at the Hartford office of this company. Bound volumes for the present year will also be ready in a few days, and may be had at the usual price of one dollar each.

THE accident to Mr. Donlin, in the Colonnade Hotel, New York, an account of which is given elsewhere in this issue, recalls an incident that happened some years ago in a New England boiler-shop. The back-head of a horizontal tubular boiler had been riveted in, and a big apprentice was sent inside to steady the front head until rivets enough could be driven to hold it in place. When some had been driven at the top, bottom, and sides, the apprentice was told he might come out. This he tried to do, but lo! he was too big to get through the manhole. The front head was removed again, and after receiving a good scare he was set free once more, and a smaller and more experienced man attended to the steadying of the front heads thereafter.

OUR Chicago contemporary, the *Stationary Engineer*, published an article in its issue for November 28th, to which we wish to call the attention of that paper and its readers. On page 422 it is said that "the Hartford Steam Boiler Inspection and Insurance Company recommend this kind of feed, but they advocate the use of 10″ and 5″ pipe, but every engineer knows that there is very little room on the top of the average boiler, and 10″ would be somewhat in the way. I got along very well with 2″ pipe."

The only authority that we can find for these astonishing statements is the article that appeared on page 38 of the issue of the THE LOCOMOTIVE for March, 1891; and in that article we particularly stated that "we recommend that the feed-pipe shall enter the front head just above the tubes on one side of the boiler, passing down the entire length of the boiler, crossing over to the other side near the back head, then turning downward and discharging between the tubes and the shell." We added that "in the West, where the water is often poor, other devices are sometimes preferred to this," and we proceeded to describe an arrangement that one of our chief inspectors has tried with success *in his locality*, and we added that "no doubt it could be used with advantage in other places where *similar conditions prevail*." If this amounts to a general, unqualified recommendation of the top or spray feed, the *Stationary Engineer's* statement is true; otherwise that statement needs to be corrected, and undoubtedly it will be. The *Stationary Engineer* is always ready to correct what it conceives to be errors in other papers, and it will probably be willing to extend the same rule to itself.

But the most amazing piece of information is, that we recommend 10″ and 5″ pipes, although our author found 2″ pipes amply large. There is nothing surely in the article cited above, nor in any other article, or any other place, that can fairly be interpreted in that manner. The dimensions in the cut plainly refer to the lengths of the pieces, and not to their diameters.

We have received a circular issued by the Phœnix Oil Company, of Cleveland, O., advertising something which they call the "Hartford scale solvent." Now, since the headquarters of the Phœnix company are in Cleveland, there is no apparent reason for them to come way over to Connecticut to get a name for their solvent, unless the idea is to profit by the reputation of the Hartford Steam Boiler Inspection and Insurance Company. It is true that our name is not distinctly used, yet the circular and the name "Hartford" are apparently intended to suggest that the solvent is advocated by us, or that its use is at least sanctioned by us. It is proper, therefore, that we should say for the benefit of our patrons that we know nothing whatever about this so-called "Hartford solvent," and that we did not even know of its existence until the aforesaid circular came into our hands.

Furthermore, the circular says that "it is now fully established by the experience of the Boiler Insurance Association [*sic*], that the great majority of explosions are caused by the weakening of the iron from strains due to unequal expansion." Where-ever did we say any such thing as that? We have endeavored to make it plain that explosions do not arise from any one cause, but from a multitude of causes, many of which have been explained in the pages of The Locomotive.

In conclusion let us say, that since we know nothing about this "Hartford solvent," we cannot say either that it is good, or that it is bad; but we wish to say explicitly that whoever uses it must do so on his own authority, and not because we have recommended it.

Typhoid Fever.

The past season has been such a dry one that unusual attention has been paid to the quality of drinking water, and typhoid fever has been a common topic of conversation among the people. It will be interesting, therefore, to review what is known concerning the cause of the disease.

For a long time it has been believed that typhoid fever is caused by certain small vegetable parasites, called bacteria, which grow luxuriantly in the intestine, the spleen, and the liver, of the diseased person, producing abscesses and the other well-known and well-marked symptoms of the disease. Various organisms were discovered by Klein and others in the discharges from diseased persons; but it was not until about 1880 that the specific bacillus, now recognized to be the cause of the disease, was investigated and accurately described by Eberth, Klebs, and Coats. (Eberth's memoirs appeared in 1880, 1881, and 1883; Klebs's in 1880; and Coats's in 1882.)

The true typhoid bacillus is rod-shaped, and is from 2 to 3 millionths of a meter long, and about one-sixth as broad. It has rounded ends, and appears to be more active, or more "alive," near the ends than in the middle. Unlike most micro-organisms, the typhoid bacillus can grow in a very weak solution of carbolic acid, and this fact has been made use of in growing it artificially, as the acid serves to weed out other organisms that may be present accidentally. It appears, therefore, that if carbolic acid is used as a disinfectant in this disease, strong solutions must be employed. Our own opinion is, that there is nothing that can compare with a saturated solution of corrosive sublimate and sal ammoniac for disinfecting purposes, its only drawback being that it is poisonous, so that it must be used cautiously and intelligently. Repeated experiments have shown (1) that corrosive sublimate *kills* bacteria, and (2) that carbolic acid acts merely by checking or stopping their growth.

The typhoid bacillus causes the symptoms of fever, not by its direct action on the patient, but because in growing it produces certain toxines, or ptomaines, or alkaloids, as they are variously called, which are absorbed into the system and act as violent poisons. This action of the bacillus seems to be similar to that which goes on in larger plants, some species of which produce strychnine, while others produce morphine, atropine, quinine, nicotine, and thousands (probably) of other alkaloids.

Typhoid bacilli can live, and even grow, in drinking water; and in milk they thrive amazingly. It is important, therefore, to know how to kill them in these and other articles of food. Janowski finds (1890) that a temperature of 131° Fah. will kill the growing bacilli in ten minutes, though he finds that five minutes' exposure to this temperature is not always sufficient. It is safe to say that boiling for five or ten minutes will make water or milk safe to use — unless they are known to be contaminated by the bacilli, in which case we should by all means recommend a change of supply.

The following characteristics distinguish the typhoid bacillus from nearly all other species:

(1) The microscope shows it to be rod-like in shape.

(2) It will grow in nutrient gelatine, but the gelatine does not become liquefied.

(3) The colonies growing in the gelatine are white, and the adjacent gelatine is not stained.

(4) The colonies form thin films on plates, and on the surface of tube cultures.

(5) The cultivations have no odor.

If the suspected micro-organism fulfills all these conditions, it must be, so far as our present knowledge goes, one of the following species: (1) *Bacillus acidi lactici*, which occurs in some milk. This species, however, is only about half as long as the typhoid bacillus. (2) The *typhoid bacillus*, or one of the three closely-allied *Pseudo typhoid bacilli*. (3) *Bacterium coli commune*, which is found in the intestinal canal of man, and which, in the deeper layers of the nutrient gelatine, grows in characteristic yellow granular disks. (4) *Bacillus cavicida*, which is found in fæces and in putrefying fluids. This is readily distinguished by the dirty yellow masses it produces when grown on moist raw potatoes. (5) The *bacillus diphtheriæ columbarum*, which occurs in pigeon diphtheria, and (6) the *bacillus of rabbit diphtheria*, are not likely to be confounded with the typhoid bacillus, because they are found under such widely different conditions. The true typhoid bacillus grows luxuriantly on moist raw potatoes, although it cannot be recognized there by the naked eye except by a peculiar moist appearance, on account of its close resemblance to the potato itself.

The general subject of bacteria is one of absorbing interest to those scientifically inclined, and is already a most important branch of human knowledge. To follow it up experimentally one needs a good microscope, a large amount of caution and forethought, and patience in an almost unlimited degree.

Some Early Forms of the Grist Mill.

We have received from Mr. J. H. Cooper a copy of the sixth volume of an *Iconographic Encyclopædia of the Arts and Sciences*, which we have examined with much pleasure. The work is translated from the German of the *Bilder-Atlas*, but it has been materially enlarged and improved. The present volume deals with Applied Mechanics, and contains a great variety of information on this interesting subject.

Mr. Cooper's well-known accuracy and his extensive knowledge of the matters treated in this volume make his writings especially valuable. The entire chapter on mills is from his pen, and he has also contributed the section that relates to the transmission of power, as well as parts of the history of the steam engine, hydraulics, wind-machines, and other subjects, on which he has spent a great deal of thought for a number of years. Portions of the chapter on mills are reproduced below.

"Of the various mechanical processes by which the condition of natural products is changed, that of pulverizing is the simplest; and the earliest human contrivances were doubtless of the nature of mills for crushing and grinding fruits and seeds. The term *mill* was originally restricted to denote the various forms of apparatus by which grain is ground into flour or meal, and the equivalent word in the Latin and its allied languages still retains this signification (Lat. *mola;* It. *mulino;* Sp. *molino;* Fr. *moulin*). In modern English usage, however, the term is applied to nearly all machines and combinations of machinery which consist chiefly of wheel-work and its co-ordinate appliances, by which raw materials are changed into new forms and conditions; and the mill generally takes its name either from the principle of its action, as 'rolling-mill,' 'saw-mill,' or from the materials upon which it acts, as 'cotton-mill,' 'corn-mill,' and the like. . . . From the earliest historic periods to the present, the edible grains have been ground between two stones. The original grinding implement was a fixed stone, in a hollowed-out portion of which the grain was pounded with a boulder in the hand. If such a crude device is worthy the name of *mill*, then, indeed, corn-mills have the highest antiquity. Dr. Schliemann, in his *Ilios*, makes mention of certain rudely-cut, nearly globular stone instruments which he found in great numbers in all the four lower prehistoric cities, and of which he says he could have collected thousands. They are of basaltic lava, granite, quartz, diorite, porphyry, or other hard and gritty stone, and in rare instances of silex. Similar implements are found in the cave-dwellings of France, and are numerous in the most ancient Swiss lake-habitations. In the opinion of Prof. Lindenschmitt, these implements, which are of the simplest kind, were the most ancient millstones, and were employed for bruising the grain on the slabs of sandstone which abound in the lake-habitations. . . . . At Wauwyl, in the canton of Lucerne, many corn crushers have been found in the villages of the Stone Age; these are balls of hard stone two or three inches in diameter. Round corn-bruisers were also found in the débris of the Stone Age of Egypt. Stone balls for bruising corn are utilized by the Indians of the Yosemite Valley, in California. Their squaws pound acorns with round-stone mullers on a granite rock, whose flat surface is worn into holes by the operation. These stationary mortars ('pot-holes') are abundant in other parts of the State. Dr. Schliemann, quoting Helbig, remarks that 'tradition has ever preserved a trace of the fact that there existed no proper apparatus for grinding at the time of the oldest Italic development, inasmuch as the *mola versatilis* — the most perfect apparatus, whose upper part was turned by a handle above the lower one — was, according to Varro, an invention of the Volsinians. This tradition, therefore, presupposed an older epoch, during which people utilized other more imperfect means, possibly with two stones, such as were used by the ancient inhabitants of the *terramare* villages for pounding the grains.' In Biblical history evidences are not wanting of the early existence of means for reducing the cereals to powder, and we may conclude that when Abraham hastened into the presence of Sarah, saying, 'Make ready quickly three measures of fine meal, knead it, and make cakes' (Genesis xviii. 6), there must have existed some sort of mill for rapidly grinding grain into flour, and to meet the demand for 'fine meal' it is evident that there was used a more efficient implement than the mill described above.

"Dr. C. C. Abbott, in his elaborate article on the 'Stone Age in New Jersey,' says, 'The Indian women, upon whom fell all the drudgery of aboriginal life, reduced the hard kernels of maize to coarse meal by pounding them in hollows of rocks, natural or artificial, with globular pebbles, or with long cylindrical stones, carefully chipped for the purpose, and known as pestles. Wooden mortars and pestles were also used. In the northern section of the State, where rocks *in situ* abound, deep basins hollowed in immovable rocks are very numerous, which is evidence that in the rocky sections of the State the site of a village was chosen with reference to the "mill," while in the southern part, where rocks suitable for mills do not exist, stones weighing twenty or more pounds are found, which were brought from a distance: a receptacle was first chipped on one side, which gradually by use became both deep and smoothly worn.' The stationary mortars are generally larger in diameter and of greater depth than the portable examples, and could be used only with the long pestles. The vast majority of these stationary mortars are natural 'pot-holes,' possibly in some cases deepened intentionally, or by long use in crushing corn. Such a pot-hole used as a mortar formerly existed in a large glacial boulder in Center street, Trenton, N. J. When excavations were made to remove this rock, several broken pestles were brought to light, besides a stone axe and several dozens of spear-heads and arrow-heads of various sizes. It is said that the present site of Trenton was the headquarters of a great chief; here the small portable corn-mills are abundant, and they were probably used solely in reducing grain to meal. Hereabouts have been found hundreds of pestles, many of which may be seen in private collections; they are cylindrical water-worn pebbles, such as abound in the bed of the Delaware river at this place. . . . .

"The mortar (*mortarium*) used by the Romans was formed of a stone or other solid material hollowed into the shape of a shallow basin, in which ingredients were kneaded and mixed with a small pestle worked by one hand in a roundabout direction. The *pilum* was a large and powerful instrument for braying materials in a deep mortar. It was held in both hands, and the action employed when using it was that of pounding by repeated blows. The Roman *pistor* literally means 'one who pounds corn in a mortar'—that is, a miller; because in very early times, before the invention of mills for grinding, the corn was brayed into flour with a very heavy pestle. Subsequently the same word signified 'a baker,' because bakers ground the flour with which they made their bread. Pliny says that, in the estimation of some, bread made of broken grain is superior to that more finely ground in the better-constructed mills; hence the inference that throughout the greater part of Italy grain for bread was pounded in a mortar with an iron-shod pestle. In course of time the mortar was ridged and the pestle notched, forming a machine which had a grating action on the grain. Dr. Tschudi describes four of the Peruvian mortars, which were carved in porphyry, basalt, and granite.

"Mortars—mostly made of hard sandstone—from five to twenty-four inches in diameter and from two to twelve inches in depth, of rude workmanship and without ornament, have been found in great numbers in graves in Santa Barbara, Cal. Specimens of the larger kind, found in graves at La Patera, are symmetrical in shape and have within and without a well-marked projecting rim, which served both to strengthen the utensil and to prevent the escape of the grain while being pounded. When broken, they were mended with asphaltum, which was also used to fasten ornaments to the rim. Many of the pestles found are simply smooth elongated boulders, while others show a shaping for a purpose, the collar on the smaller end suggesting a provision for suspension, or to facilitate handling. . . . . Hunter, in his *Manners and Customs of Indian Tribes*, informs us that in some Indian villages visited by him there were employed for pounding corn one or two large stone mortars, which were public property. These were placed in a central part of the village, and were used in rotation by the different families.

"In the course of time the cavity of the stationary stone became deepened, and a handle was attached to the ball, whereby there resulted the mortar and pestle; so, again, when the upper stone was enlarged and provided with a central hole and a handle, by which the stone was rotated on a peg or pivot in the lower stone, there was produced the quern or hand-mill, which is the germ of the modern flour mill.

"Wheel mills consist of a single pair of stones of similar form, with fitting surfaces, one of which (the upper stone or runner) is caused to revolve in near contact with the other (the nether or bed-stone), the grain being ground between the two while passing in a direction from the center to the circumference. By both ancient and modern writers the term 'corn-mill' has been applied to a mortar-and-pestle mill as well as to a mill composed of a pair of stones, one of which is fixed, while the other revolves. In connection with the earliest Scripture reference to the 'mill' (Numbers xi. 8), there is mention of the use of the 'mortar,' both of which implements were employed for reducing manna to powder. We have no description of the form of the mill in which the manna was 'ground,' but we may presume that revolving mill-stones were employed. At an earlier date the 'king of Salem brought forth bread and wine' (Genesis xiv. 18), from which we may infer that mills for grinding grain and machines for expressing the juice of grapes were employed in the earliest times.

"The Etruscans (500 B. C.) scored or furrowed the inside of their mortars, grooved the bottoms radially, gave to them a more cylindrical form, and roughened the lower end of the pestle. The pestle was kept in the central position by an iron spike projecting from its lower end and entering a hole in the center of the mortar, and it was rotated on its vertical axis by means of a handle projecting laterally."

A few days ago the skeletons of five mound-builders were discovered at Chillicothe, Ohio, by Warren N. Moorhead. Two of the skeletons were covered by a sheet of copper six feet wide and eight feet long, and numerous other copper articles were found also. The most remarkable among these was a copper axe weighing forty-one pounds, with a sharp cutting edge seven inches long. This is by far the largest specimen of this kind yet found. Remains of a wooden stool, covered with sheet copper, were found near one of the skeletons. Thirty plates of the same metal, with mound-builders' cloth on them, and a great copper eagle, twenty inches in diameter, with wings outspread and beak open, are also described, and the eagle is said to be one of the most artistic designs yet found.

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