Round the Works of Our Great Railways

NEW NARROW GAUGE ENGINE, NO. 3014.

ROUND THE WORKS

OF

OUR GREAT RAILWAYS

BY VARIOUS AUTHORS

With Illustrations

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From Official Photographs.

ROUND THE WORKS

OF

OUR GREAT RAILWAYS.

CHAPTER I.

THE LONDON AND NORTH-WESTERN RAILWAY WORKS AT CREWE.

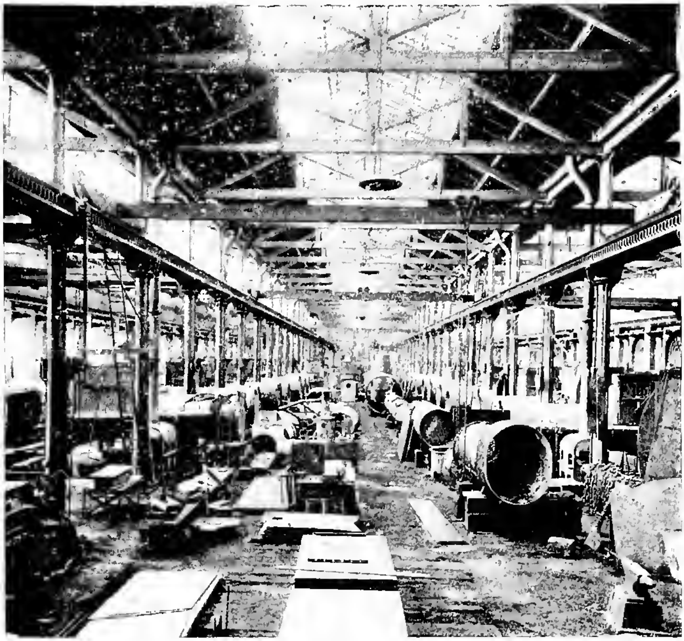
By C. J. BOWEN COOKE,
[Assistant Running Superintendent, Locomotive Department.]

THERE is no busier railway station in the country than Crewe, the principal junction of the London and North-Western system. Through it more than six hundred passenger and goods trains run every twenty-four hours. The locomotive works which extend for a mile and a half in length are situated in the fork of land between the Liverpool and Chester and Holyhead lines, close by the side of the latter; but before describing what may be seen inside these works, I will say a few words about the town in which they are situated.

Crewe has no architectural pretensions, but consists principally of small red-brick houses, inhabited by working-men all in the service of the Company. Its rise and progress are contemporaneous with the development of the London and North-Western Railway Company. Sixty years ago on its present site it contained a population of one hundred and forty-eight souls. On July 4, 1837, the first train passed through this small village on, what was then called, the Grand Junction Railway.

OFFICES OF THE LOCOMOTIVE DEPARTMENT.

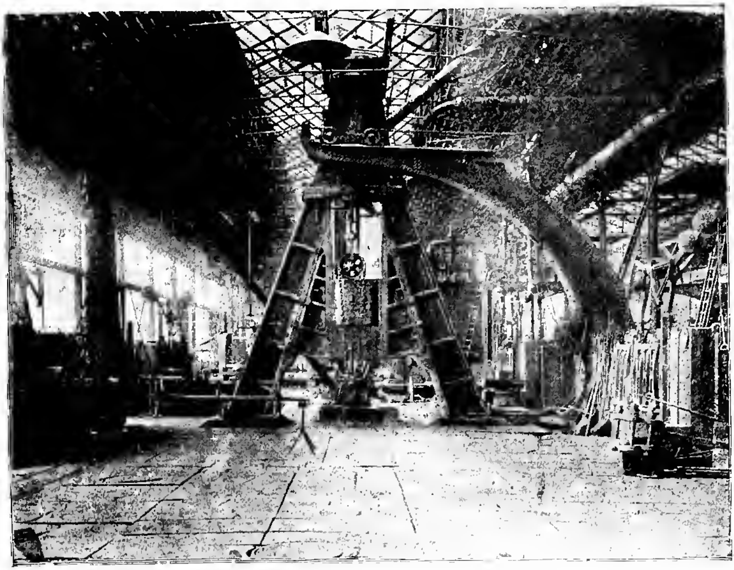
An amalgamation was in that year effected between the Manchester and Liverpool, the Manchester and Birmingham, the London and Birmingham, and other lines. The new Company was called the London and North-Western, and in August 1842, the complete line, so far as it had been constructed, was opened to the public. The authorities connected with this great undertaking were not slow to perceive the central situation of Crewe. It was apparent that several lines must converge there, and that it would thus become a great meeting-place for railways.



BOILER SHOP.

It was seen, too, that the place would be an admirable site for the construction of locomotive engines, carriages, and wagons, the result being that in 1843 the Grand Junction Works, which had previously been situated at Edge Hill, Liverpool, were transferred to Crewe, and from that time the development of the town began. In 1853, however, the wagon department was removed to Earlestown, and in 1861 the carriage department was transferred to Wolverton, and so the Crewe Works are now entirely given up to the manufacture of locomotives. In 1841 the population of Crewe was 203, having increased only fifty-five in ten years. In 1851, eight years after the establishment of the works, the population had risen to 4,571; in 1861 it was 8,159; in 1871 it had increased to 17,810; and at the present time it is 30,000. In 1843 the works occupied from two and a half to three acres of ground, the number of men employed being 161. They now occupy 116 acres, thirty-six of which are covered; the number of men employed being upwards of 7000. In May 1876 the completion of the 2000th engine was signalized by public rejoicing. On July 4, 1887, the 3000th engine was completed.

Crewe possesses a Mechanics' Institute, built and supported by the Company. Excellent science and art classes are connected with the Institute, and its students have won more Whitworth Scholarships than any other place in the country. It has also a well-stocked library and good reading-room. There is a Volunteer Engineer Corps, 600 strong, composed entirely of men employed in the works. A well-trained Works Fire Brigade has its depôt close to the offices, and in case of a fire breaking out while the men are off duty, they can be instantly summoned by means of electrical communication which is established between the "Time Offices" at the works and the house of each member of the brigade. With the exception of two sewing factories employing female labour, there is no other source of employment whatever in Crewe, except that afforded by the Railway Company. The Parliamentary division is named after the town, which comprises more than half the electorate. In 1848 the Queen, Prince Albert, the Prince of Wales, and other



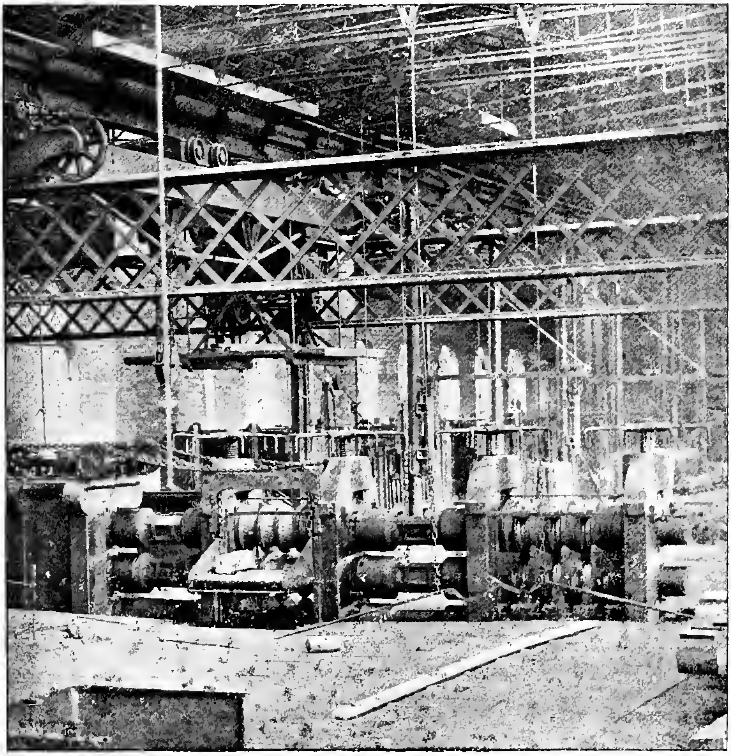
EIGHT-TON STEAM HAMMER.

members of the Royal Family, paid an unexpected visit to the town, and stayed the night at the Crewe Arms Hotel, on their route to London from Scotland. The Royal Family had set sail from Aberdeen for Portsmouth, but meeting with very stormy weather, the Queen decided to return to Aberdeen and proceed overland.

The whole party feeling fatigued, her Majesty sent word shortly in advance of the train's approach to Crewe that she would stop at the hotel there for the night, which she accordingly did, proceeding on her journey the next morning. There is probably no other place without a history which has been visited by more distinguished and learned people than the great locomotive workshops of the London and North-Western Railway Company.

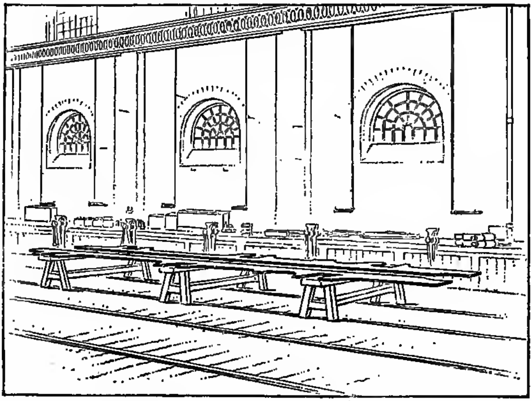
Mr. F. Trevithick was the first Locomotive Superintendent at Crewe. He was the son of the great Trevithick who in 1805 exhibited his wonderful "steam coach" on the site now occupied by the London and North-Western Railway Terminus at Euston. At this time, however, the Company had only seventy-five engines in stock. He was succeeded in 1857 by Mr. Ramsbottom, who effected many important improvements; and in 1871 he was followed by Mr. Francis William Webb, the present Chief Mechanical Engineer and Locomotive Superintendent. Mr. Webb served his apprenticeship at Crewe Works, and has been connected with them for thirty-five years, acting as manager during Mr. Ramsbottom's superintendence, and it is owing to his ingenuity that the North-Western Railway possess upwards of fifty patents for improvements connected with railway plant, ranging from a foot-warmer to a locomotive.

We will now suppose ourselves to have arrived at Crewe Station, armed with a letter of introduction to enable us to see the works; for be it strictly noted, that without this "open sesame" the doors are closed to visitors. We have then to make our way through the town to the "General Offices," which form the starting-point for detouring over the works. These offices are situated in the centre of the town, and also of the works.



RAIL MILL, CREWE WORKS.

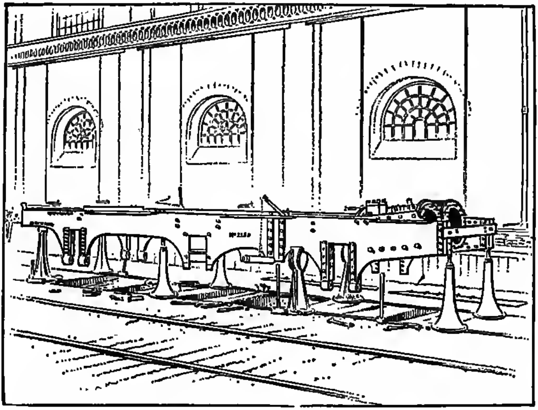
Having signed our names in the "Visitors' Book" we are placed in the care of a guide, and begin our journey of inspection. We pass out of the offices through a spacious doorway on the works side, and are agreeably surprised to see the verdant freshness which meets the eye all around, instead of the grimy appearance which might naturally be expected. The offices, which are lighted throughout by electricity, extend several hundred yards in length, and face some lines of rails connecting the old and new works. A well-kept border of grass



ENGINE ERECTED IN TWENTY-FIVE HOURS AND A HALF.
FIRST STAGE AT SIX A.M. MONDAY, FEB. 4TH.

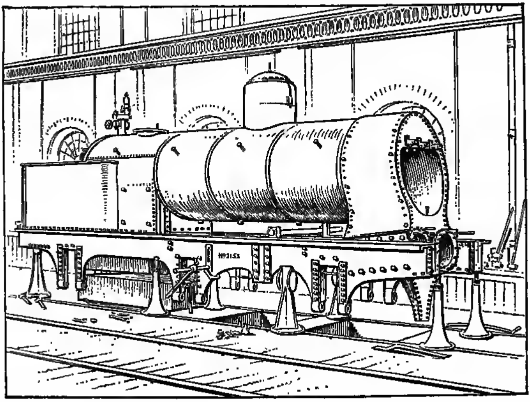
several yards in width and studded with evergreens runs along the whole length of the building, and ivy climbs its walls. The residence of Mr. Webb is close to the end of the offices, and notwithstanding the immense amount of fuel burned in the works, such is the purity of the atmosphere, owing to the use of gas furnaces and smoke-consuming appliances, that luxuriant vegetation and beds of flowers surround the house. The Drawing, Stores, Accountants', Running and Signal Offices, Photographic Studio and Laboratory, together with the private offices of the Superintendent and heads of departments, are concentrated here. Many hundreds of clerks are engaged in them who record every pound of coal burned, every mile run, every item of expenditure in any shape connected with the building, repairs, or working of each individual locomotive.

Upon emerging from the offices we find waiting for



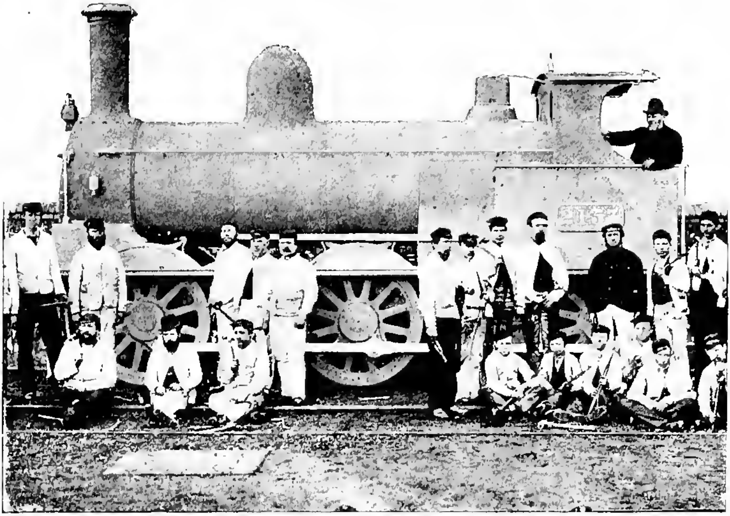
ENGINE ERECTED IN TWENTY-FIVE HOURS AND A HALF.
SECOND STAGE AT ONE P.M. MONDAY, FEB. 4TH.

us a vehicle called by Crewe Works people a "cab," which is a low kind of covered truck attached to a locomotive, several of which are run on the railway lines about the works to convey either men or material from one part to the other. We step into it, and are at once conveyed to the Steel Works, which is usually the first place to which visitors are taken. Here we see the manufacturing of steel by the Bessemer process. This is the first step towards the making of a locomotive, viz. making the steel which is so largely used in its composition. About five tons of pig-iron, previously melted in a cupola, are run into a "converter," which is a large egg-shaped vessel with a gigantic kind of spout. This vessel is then revolved on its own axis until the spout points upwards, and then a strong blast of air is turned



ENGINE ERECTED IN TWENTY-FIVE HOURS AND A HALF. THIRD STAGE AT ONE P.M. TUESDAY, FEB. 5TH.

into the metal from below, which acting upon the molten mass keeps up a fierce combustion, and ejects all the impurities from the iron. This "blowing" is kept up for some fifteen or twenty minutes. Showers of glittering sparks and a fierce roar of flame shoot out of the upturned orifice, and at night light up the whole place in a weird, fantastic way. When the "blowing" has ceased the "converter" is again turned down, and a quantity of "spiegeleisen," an iron highly charged with carbon, which has been previously melted in a furnace, is poured into it. This chemically combines with the molten iron, and the result is Bessemer steel. The mixture is then emptied into a huge ladle suspended at the end of a crane, from whence it is poured into the various moulds standing ready, and is cast into ingots, to be used for making rails,

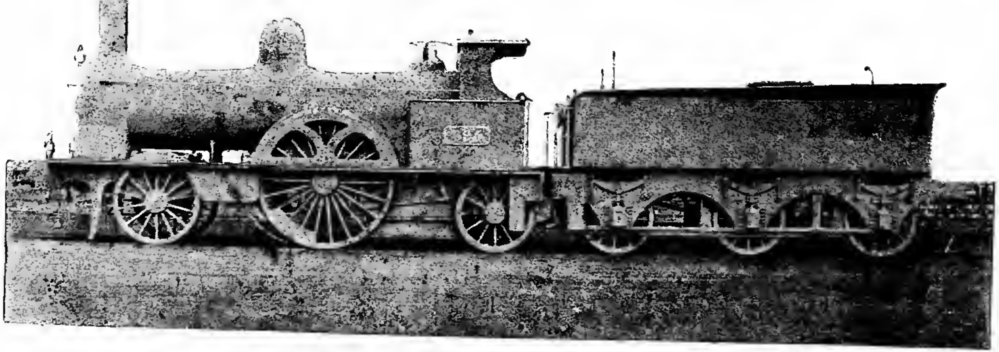


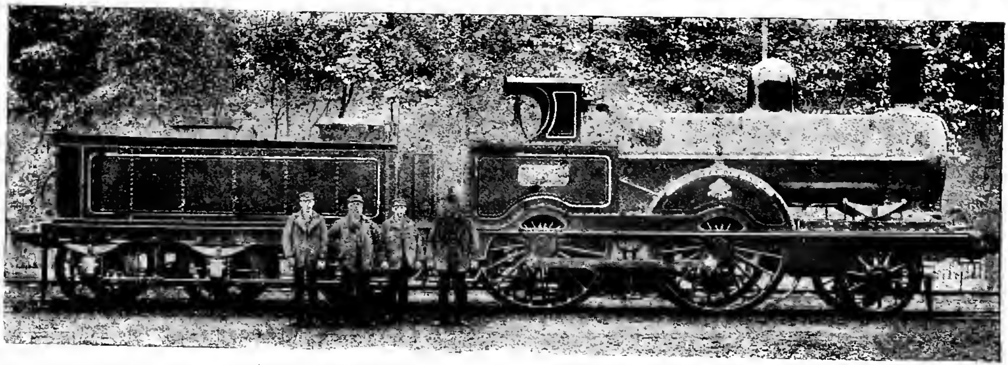
ENGINE ERECTED IN TWENTY-FIVE HOURS AND A HALF. COMPLETED ONE P.M. WEDNESDAY, FEB. 6TH: AND WORKMEN.

tyres, axles, plates, or any other purpose required. We glance at the splendid horizontal engines supplying the converters with air, and passing by the furnaces (of which there are seven) for making steel by the Siemens-Martin process, we go on to the Rail Mills.

The North-Western is the only English railway that rolls its own rails. The plant has a capacity for turning out 45,000 tons of rails annually, the actual output being 25,000 tons. The mill is driven by a magnificent 700 horse-power engine of the Corliss pattern. An ingot similar to one we have just seen cast is taken out of a furnace to the mouth of the largest of the swiftly revolving rollers of the mill. This ingot is about 3 feet long by 10½ inches square. The rollers may be compared to a large mangle, and the ingot in passing to and fro between these is first transformed into a thick bar of steel; with each squeeze it becomes longer and thinner, the last few times the top and bottom of the bar flatten out, and the middle becomes thinner until it emerges from the last pair of rollers. It is then carried on small rollers to a circular saw close by, the ends are cut off square, and we behold a perfectly finished rail thirty feet long, and weighing ninety pounds to the yard, in about a minute from the time we saw the ingot enter the first pair of rollers.

We now visit the Forge, where we see a thirty-ton Ramsbottom duplex hammer at work. Two blocks, each weighing thirty tons, are being driven horizontally to and from each other by steam power, and are pounding away at a mass of white-hot metal between them. An enormous force is here made use of without the vibration caused by a vertical hammer descending on a block. We see at work eight of these latter hammers of various size and power, ranging from sixteen hundredweight to eight tons. Here are also plate-rolling and shearing machines; the former transforms huge blocks of hot metal to thin plates of steel or iron with the same ease and dexterity as the busy housewife converts a


WOLVERTON BLOOMER ENGINE, "TORCH."


"CHARLES DICKENS," AND DRIVERS AND FIREMEN.

lump of dough into a thin pie-crust, and the latter emulates the same individual plying her scissors, for it snips and cuts up great pieces of cold iron and steel with equal facility. The plate-rolling machines perform the important part of making all the plates from which the engine boilers and frames are constructed. Here also Mr. Webb's patent steel sleeper is rolled, over 100,000 of which are laid down in the present permanent way of the Company. A large circular saw, seven feet in diameter, driven at a speed of 13,000 feet per minute, demonstrates its power by cutting through an iron axle nine inches in diameter in thirty seconds. The metal which has to be treated is all heated in gas furnaces, of which there are thirty-seven, the gas being generated in forty-nine gas producers, and conveyed to the furnaces in underground pipes.

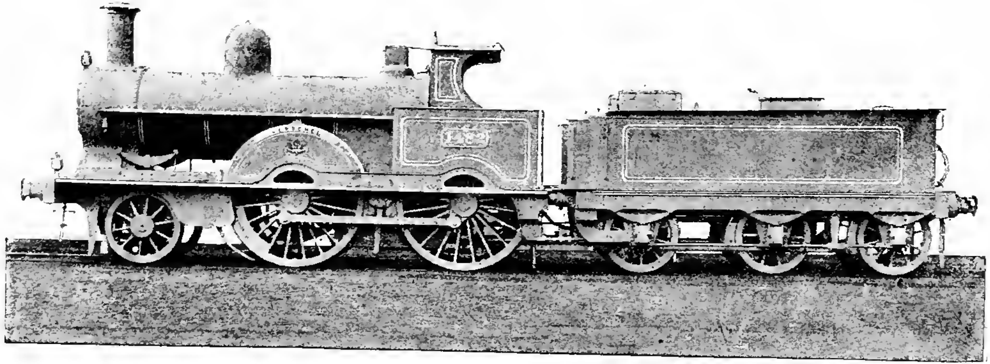
Our next visit is to the Boiler Shop, where we see engine boilers in every stage of construction. The barrel-shaped part of a locomotive boiler has in it upwards of 200 tubes extending from the "fire-box" to the chimney end. These tubes when the engine is "in steam" are surrounded by water, and the flames pass from the furnace to the chimney through them, the greater the number of tubes, the greater the "heating surface" acted upon by the fire to generate steam. The fire-box is the most costly part of an engine, being made entirely of copper, the tubes are usually brass and the rest of the boiler steel; more than a million tubes are used annually for new boilers and repairs. These tubes and the copper plates for the fire-boxes are the only things imported into Crewe Works in a manufactured state. The noise of hundreds of men closing rivets up is deafening, and we leave this place with a sense of relief.

At the extreme end of the works near the Boiler Shop there is a large brick-making plant; the yearly output from a circular kiln being over five millions. Passing through the Flanging Shop, where the fire-box and tube plates are flanged in a powerful hydraulic press, we go to the Engine Repairing Shops, which are a counterpart of those we shall see at the Old Works, and on to the Tender Shop, where tenders are in all stages of manufacture and repair. The London and North-Western Company's tenders are fitted with an ingenious apparatus —the invention of Mr. Ramsbottom—for picking up water while travelling. A pipe called a scoop, with a bend at the end, is let down into a water trough between the rails while the engine is passing over it, and the rapid motion of the train forces the water up the scoop into the tank on the tender. This system enables the tenders to be constructed of a lighter pattern, and avoids the necessity of carrying a large supply of water; thus reducing weight and consequently working expenses.

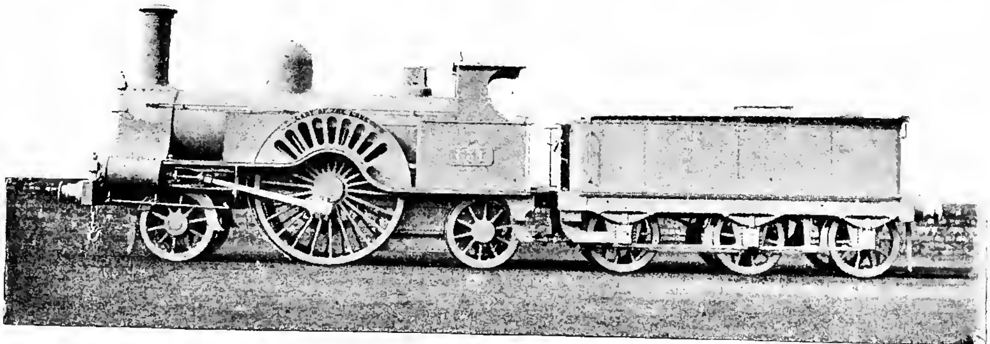
Our next visit is to the Iron Foundry, where moulders are making, with wood and metal patterns, the shapes in the sand into which liquid iron is afterwards poured, and which subsequently come out in the form of cylinders, wheels, and all parts of locomotives, signal gearing, and other machinery for which cast-iron is used.

We next pass the Brass Foundry, where all sorts of brass castings are made, and enter the Signal Shop where all the signal apparatus is fitted. The signal frames are all put up temporarily in this shop before being conveyed to the signal boxes wherever they may be required along the line. This is a department which has made very rapid strides since the first introduction of railway signalling. The old-fashioned "policeman"—still bearing that name on many parts of the line—with his long-tailed coat and stove-pipe hat, whose only duty was to wave a flag by day or a lamp by night, has long been superseded by the highly-trained "signalman," who has to pass a strict examination in all the complicated details of block working, which requires intelligence and constant attention upon the telegraph instruments and signal levers. In this shop the Webb-Thompson electric staff apparatus, now being largely adopted in single line working, and which ensures the safe and economical transit of trains over such lines, is pointed out to us.

Passing the large Paint Shop on the left, where the engines receive their final treatment before leaving the works, we begin to retrace our steps towards the Old Works lying in the direction of Crewe Station. We first enter the "Deviation Works,"—so called owing to the Chester line being here deviated to run outside the works, it having formerly run within at that point. At this place carpentry, joinery, pattern-making, and wood-working of all descriptions is carried on. Here are some very wonderful machines, perhaps of even a more interesting character to the non-scientific mind than many of the metal work machines. A machine, controlled by one man, seizes hold of a log of wood and then saws, planes, slots, drills, adzes, and turns it out a finished buffer plank in almost as short a time as this sentence can be written. This machine, called a "General



"HERSCHEL." FOUR-WHEEL COUPLED PASSENGER ENGINE. SIX FEET SIX INCH DRIVING WHEELS.



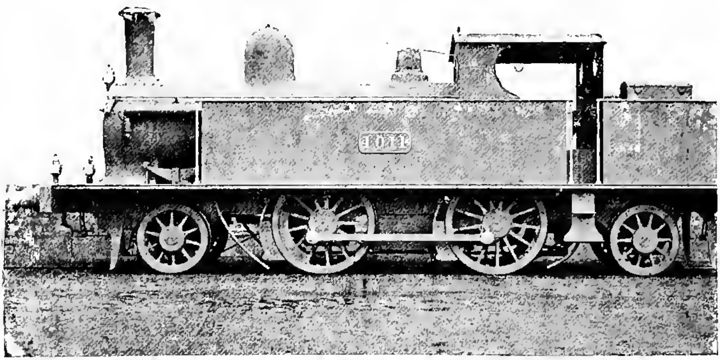
"LADY OF THE LAKE." EXPRESS ENGINE. SEVEN FEET SIX INCH DRIVING WHEELS.

Joiner," and many others of an equally astonishing character, for planing, sawing, morticing, rabbeting, and labour saving in every way, are to be seen on every hand. One very interesting machine makes the handles of axes, hammers, and other tools. An iron pattern of the exact size of the handle to be made guides a rapidly revolving tool, causing the point of it, as it travels along, to describe a shape exactly like the iron pattern. This tool, brought in contact with a revolving piece of wood, cuts it out to precisely the required shape in a few minutes. Another machine performs the astonishing feat of drilling a clean-cut *square* hole.

There is some very interesting machinery in the Saw Mills. A band saw fifty-five feet in length of great power has lately been added. This saw is about four inches wide, and is capable of cutting through a block of wood six feet thick in an incredibly short time. The machinery in the Joiners' Shop and Saw Mills is all driven from shafting fixed in the cellars below. This has rather a curious effect, as ordinarily in a shop full of machines there is a bewildering maze of belts and innumerable pulleys, whereas here the motive power is completely hidden. Underneath the Saw Mills is to be seen some of the finest belt-driving machinery in the world. The transmission of about ninety horse-power from one part of the building to another is effected by an arrangement of large pulleys and belts, these working with the least possible friction and doing away with the wear and tear of bevelled cog-wheels and other expensive machinery.

We now pass on to the Pattern-Makers' Shop, where men are engaged making patterns for castings. These have to be made with the greatest accuracy, and are put together in sections to enable the moulder to draw them out of the sand without injuring the shape of their imprint. The size of the pattern has to be so calculated as to ensure the casting to be of the right dimensions after the metal has shrunk in cooling. There is an immense number of patterns stored away in this shop ready for use at any time whenever a casting may be required from any one of them. In the adjoining Millwrights' Shop we observe mechanical engineering work in almost every conceivable branch going on : cranes, warehouse machinery, stationary engines, electrical, hydraulic, marine, and all kinds of machinery are in course of construction or under repair. Close by is the Testing and Chain-Making Shop, where all kinds of chains, samples of steel made in the works, pieces of each boiler plate that is to be used, and other material, are subjected to severe tests by hydraulic and other machinery to see whether they can satisfactorily stand the stress of work which will be put upon them in the particular service for which they are intended.

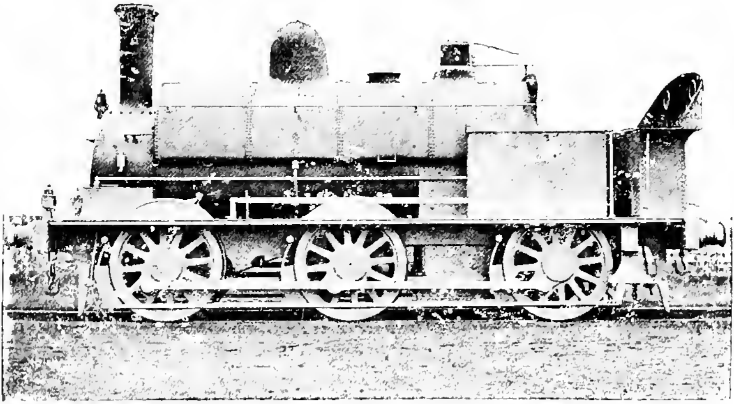
Again mounting the friendly "cab," we are whisked off to the "Old Works," which are entirely devoted to the manufacture and repair of locomotives. We are first shown a novel machine, called an "electric welder." By its means pieces of metal are joined by fusion together through the heat which is generated at the points of contact by an electric current. This enables welds to be made in parts which could not otherwise be got at without taking the object to pieces ; in fact, many things which are welded by it could not be done by any other means; and as it does its work expeditiously, it is an excellent labour-saving machine. Having watched the process, we enter the Smithy, in which there are 120 smiths' hearths, at each of which men are busily engaged. Each fire is connected by a tube to a pipe in which a strong current of air is compressed by a fan, and in order to obtain a draught to his fire, all the smith has to do is to move a handle which turns on the blast of air



EIGHT-WHEELED SIDE TANK ENGINE. FOUR-WHEEL COUPLED FOUR FEET SIX INCHES. CYLINDERS SEVENTEEN BY TWENTY INCHES.

from the pipe. Here various, principally the smaller, parts of engines are forged. When the Shah of Persia visited the works he witnessed in this shop a large forging operation under a steam hammer, and the cascade of sparks sent forth by the first blow from the ponderous machine falling among the group of spectators so worked upon the feelings of his Majesty that he beat a hasty retreat, preferring the request that spectacles of a less alarming character should be brought under his notice.

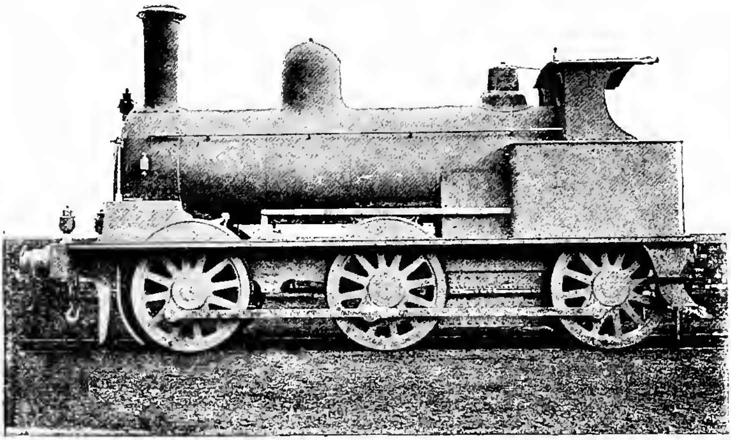
We now proceed to the Erecting Shop, where engines are in all stages of construction. The different parts which have been manufactured in other shops all ultimately find their way here, and are put together piece by piece until the whole machine is completed. First the frame plates (which are made at the plate mills at



SPECIAL TANK ENGINE. SIX COUPLED WHEELS FOUR FEET THREE INCHES. CYLINDERS SEVENTEEN BY TWENTY-FOUR INCHES.

the Steel Works) are fixed by temporary cross bars into exactly the same position they will occupy when the engine is completed. This is the ground-work from which the engine is built up. The cylinders and foot-plate are then fixed in position, and other work done to complete the skeleton. The boiler, which has already been completed and tested at the boiler shop, is then put on, being lifted into position by an overhead crane; after this has been fitted the engine is again lifted by the cranes, and the wheels, which are made at the Steel Works and are usually cast steel, and to which the axles and axle-boxes have already been fitted, are run under and the engine lowered down on to them. The internal working parts, such as connecting rods and intricacies of the valve motion, are then fitted in their proper places, and all the internal and external fittings completed. Between the steel boiler plates and the outside casing, which is made of plates of thin sheet-iron, there is a layer of thick felt, which prevents the loss of heat that would take place if the boiler plates were exposed to the atmosphere. The engine being finished, it is lifted bodily up clear of all obstructions and carried by the two powerful overhead travelling cranes to the central gangway, where it is run out on a pair of rails, got in steam, and sent for a trial trip before going to the Paint Shop, from which latter it is sent forth ready to take up its duties on the line. The usual time taken in constructing an engine is four weeks; but, as an experiment, one was once built in twenty-five and a half working hours.

In the Repairing Shops, adjoining the "new work" Erecting Shop, are veteran heroes of the road, minus wheels, boilers, and internal fittings, stripped so as to be very much in the same state as some of the new engines we have seen in the most embryo condition, but which in time will be turned out renovated and improved up to date, so as to be able to compete with their brand-new sisters who are only just starting upon their career. These shops are divided into a number of sections, in each of which three engines are in course of construction, or under repairs. Each of these sections is called a "pit," and is under one man, called a "leading hand," who has a certain number of men under him, and is responsible for the workmanship of the engines erected or repaired under his supervision. Over 2000 engines are repaired annually. In the adjoining Wheel Shop the wheels and axles are turned; and here is some of



COAL ENGINE. SIX COUPLED WHEELS FOUR FEET THREE INCHES. CYLINDERS SEVENTEEN BY TWENTY-FOUR INCHES.

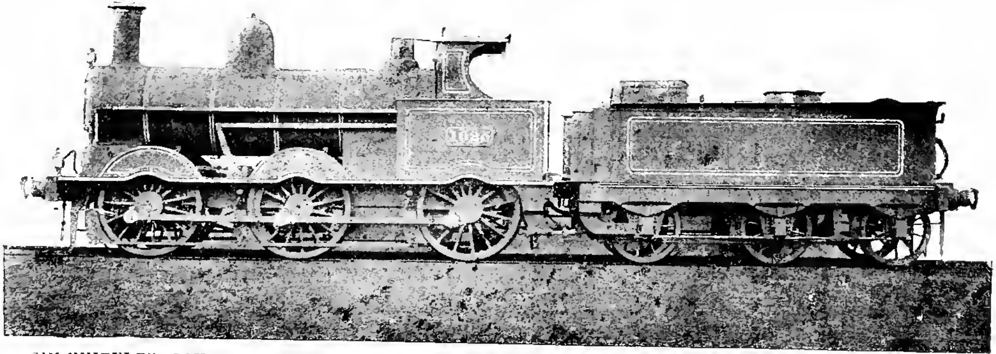
the most powerful machinery to be seen in the works. Some of the wheel lathes are splendid pieces of mechanism, capable of turning wheels nearly nine feet in diameter. One machine called a "roughing lathe" has seven tools all employed at once in taking a rough cut off the crank axle, tearing the steel away in huge bites, and making the axle ready for the finishing tool. A "nibbling machine," with 160 cutting tools, eats its way into the solid forging of a crank, and cuts out the "throw" or inner bend of the crank.

We are next shown the Fitting Shops, which are perhaps kept by our conductor as a *chef d'œuvre* to finish the round of wonderful sights. To the visitor this is perhaps the most marvellous place in Crewe Works. A perfect maze of pulleys, straps, shafting, revolving wheels, and machinery of every description presents to the bewildered spectator a scene which he is never likely to forget. The space permitted by this article is too limited to admit of any detailed description being given of it; suffice it to say that machines and appliances of every kind devised by human ingenuity crowd upon the eye in all directions. Lathes, emery wheels, grindstones; planing, shaping, slotting, boring, and drilling machines are busily working upon all the different parts used in making a locomotive. Cylinders, pistons, valves, connecting rods, axle-boxes, air pumps, slide bars, lubricators, and the numerous pieces of which an engine is constructed, are here perfected and made ready to be fixed in their proper places in the Erecting and Repairing Shops. A very clever machine for cutting in a brass plate the name of the engine on which it is to be fixed may be alluded to. The required letter sunk in a die is traversed round by a guide, which causes a tool to work in exactly the same lines in a brass plate, cutting out the letter in an incredibly short time with the greatest ease to the operator.

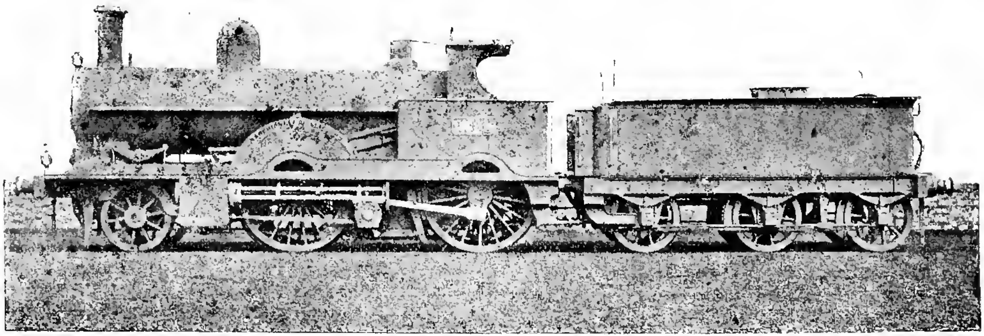
One great principle with regard to engine fittings at Crewe is having them all made to a "standard." For instance, one pattern of "connecting rod" is interchangeable with about two thousand engines. The enormous saving in this system can be seen at a glance. All such fittings are made "piece work," the men becoming very expert at the particular job they are engaged upon. The different articles are thus made in the most expeditious manner possible, and are ready to put up in their places without any further fitting. Should any particular part of an engine fail at an out-station, a wire to Crewe giving the number and letter by which the part is designated, brings a finished article direct from the stores by the next train, and the engine can be got to work again with only a few hours' delay.

We have now reached the end of our tour of inspection, which has of necessity been very cursory, and as we stand by the building in which the works' stores of materials are kept, we see across the labyrinth of rails to the right the "steam shed," in which one hundred and forty engines are stabled. There an army of "cleaners" are constantly, night and day, engaged in cleaning iron horses coming in after performing their journeys, and preparing them for fresh ones. Before us is a bridge stretching across the lines from the works to the platform of the station, a distance of several hundred yards; along the bridge and winding in and out of the works, covering a distance of five miles, is a narrow gauge line eighteen inches in width, on which little engines with appropriate names, as "Tiny," "Midget," &c., run, conveying goods wherever they may be wanted.

This review of Crewe Works would be incomplete if I failed to give some particulars of the various classes of engines made in them. I will therefore describe them as briefly as I can. The first illustration of a locomotive is one of the type called "Bloomer," an express passenger engine built by Mr. McConnell about the year 1847, at the time when the southern section of the line had its head-quarters and separate locomotive works at Wolverton. The illustration shows the engine as rebuilt at Crewe. This engine did excellent work in its day, but the pattern is now obsolete, having had to give place to modern improvements with the advance of engineering development. In bygone years the performances of these engines stood second to none. The "Lady of the Lake," an engine with single driving wheels, is perhaps one of the prettiest engines that was ever built. The details of its design were worked out by Mr. Webb when in the Crewe Drawing Office under Mr. Ramsbottom. It is capable of running at a very high speed, although not heavy enough, and the single driving wheels not having a sufficient grip on the rails, to work an ordinary express train of the present day. It is nevertheless very useful for light trains, and ran the 10 A.M. Edinburgh express between London and Crewe, which consisted of only four coaches, at the time of the race to Scotland in the summer of 1888. On one of these runs the speed maintained from Tring to Bletchley was between seventy-five and eighty miles an hour. North of Crewe, however, the train was worked by one of Mr. Webb's coupled engines with 6ft. 6in. driving wheels, of the "Charles Dickens" class. These engines have until recently been the standard express engines in use. The "Charles Dickens" is now a famous engine, and well known to every habitual



SIX-WHEELED COUPLED EXPRESS GOODS ENGINE. FIVE FEET DRIVING WHEELS. CYLINDERS EIGHTEEN BY TWENTY-FOUR INCHES.



COMPOUND EXPRESS PASSENGER ENGINE, "MARCHIONESS OF STAFFORD." SIX FEET DRIVING WHEELS. SHOWN AT INVENTIONS EXHIBITION.

traveller between Manchester and London. Since February 1882, this engine has run daily a double trip between these points, except when, of necessity, stopped for repairs, and on the 12th September, 1891, it completed its 2,651st trip, having accomplished the extraordinary feat of running 1,000,000 miles in nine years 219 days. During this time, in addition to the Manchester and London trips, ninety-two other journeys were made; the total amount of coal consumed by it during the period being 12,515 tons.

The ever-increasing weight of trains, caused by improved carriages, &c., and greater speed desired by the public, caused the frequent use of "pilot" engines—a term used to describe the assistant engine when there are two attached to a train. This led Mr. Webb to consider the question of designing more powerful engines. He determined upon trying the experiment of applying the "compound" principle to an express passenger locomotive, with the idea that such an engine, properly constructed, would possess many advantages, and prove economical in working, in addition to attaining the desired result as regards increased power. The principle of a compound engine is this: the exhaust steam from the high pressure cylinder instead of passing away direct through the chimney (as is the case with an ordinary simple high pressure engine) is conveyed from one cylinder at a high pressure into another of larger diameter, where at a lower pressure it is again expanded and acts upon the piston and crank of a second pair of driving wheels, and made use of to the greatest possible extent before being discharged into the atmosphere, thus doing a maximum amount of work at a minimum cost. Mr. Webb's system is an arrangement of three cylinders, two high pressure, acting on the rear, or "trailing" wheels, and one low pressure inside cylinder (into which the steam passes from the two outside cylinders) driving the middle wheels. The first compound engine built was named "Experiment," and the results obtained from it, and others of the same pattern, were so satisfactory, that this type of engine, enlarged and improved in many details, is now recognized as the standard London and North-Western express passenger engine.

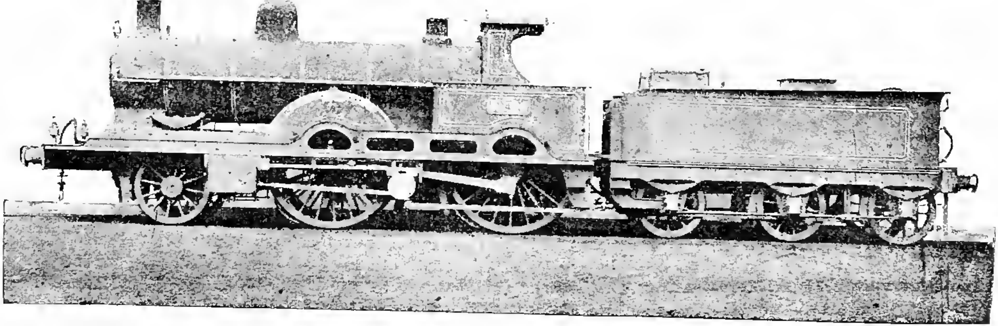
The "Marchioness of Stafford," a splendid specimen of this class of engine, with 6 ft. driving wheels, was exhibited at the Inventions Exhibition ; it was awarded a gold medal, and was an object of much interest. The "Jeanie Deans," which was exhibited at the last Edinburgh Exhibition, is an engine with 7 ft. driving wheels, and represents the latest batch of compounds turned out of the works. This class of engine is—with the one exception I shall mention directly—the most powerful that has been made at Crewe, and the increased size of the driving wheels renders it capable of attaining a higher speed than the others. The "Jeanie Deans" at the present time may be seen any day on the 2 P.M. Scotch express from Euston. This is one of the heaviest and fastest trains on the line. It consists frequently of from eighteen to twenty vehicles, among which are the heavy dining cars. But the driver, although not disdaining a pull up the one in seventy gradient to Camden Town, to obtain a good start, would scorn the idea of "Jeanie Deans" taking a "pilot," and he rattles his big load away down the country as easily as the "Lady of the Lake" took her four carriages with the Scotch racing train.

Mr. Webb's most recent achievement in compounds is the engine "Greater Britain." This is perhaps the most powerful engine that has ever been built. Although heavier than any other that has been made at Crewe, it is so constructed that there is no more than the usual weight on any one pair of wheels, and there is therefore no extra strain on the permanent way or bridges. This is brought about by the two pairs of driving wheels being placed in front of the fire-box, and an additional pair of small wheels, behind the fire-box and underneath the foot-plate, having half an inch of side play. The wheels under the front, or leading end, are fitted with Mr. Webb's patent radial axle-box; so that, although of great length, the engine can travel over curves with complete safety. One of the chief features is the combustion chamber inside the barrel of the boiler, which has the effect of arresting the gases from the fire-box on their way to the chimney, causing all the heat developed by them to be made the utmost use of for generating steam. This engine has attracted great attention in the engineering world. The London and North-Western engines collectively consume 3,095 tons of coal per day; and seeing that compound engines have been proved in actual working to consume about six pounds of coal per mile less than other engines on the same work, and that they are daily taking loads without assistance, which any other type of engine would require two engines to work, it is evident that their invention and adoption has been of material advantage to the London and North-Western Railway Company.

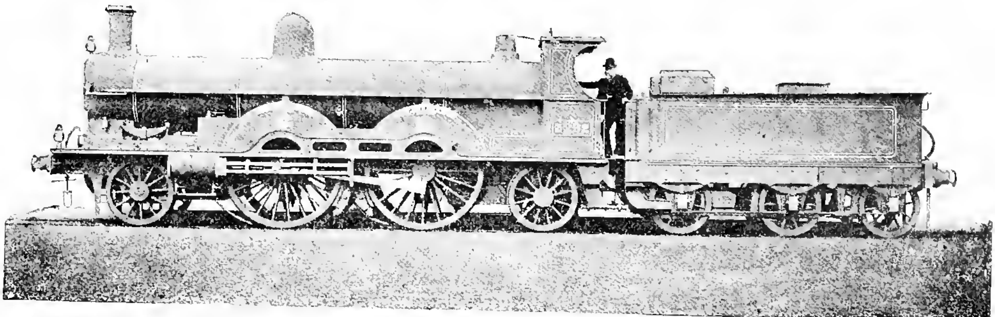
The illustration of the "Herschel" represents a class of engine originally built by Mr. Ramsbottom, which for many years was the most powerful express engine owned by the Company. Increased weight and speed of trains, however, rendered it not up to modern requirements, and most of the "6 feet 6 inch Ramsbottoms," as they were called, have been rebuilt by Mr. Webb, and have now cylinders and boilers the same size as the "Charles Dickens" pattern.

The goods engine with six coupled wheels five feet in diameter was designed by Mr. Webb. It has cylinders 18 inches in diameter, and is used for running the more important through express goods trains. A coal engine, by the same designer, is the standard pattern of engine used for working the heavy coal and mineral traffic. This engine is capable of working trains on the main line, consisting of forty-five loaded coal wagons, the total weight of such a train amounting to over 600 tons. The standard type of shunting engine is called a "Special Tank." This engine carries the water for feeding the boiler in a semi-circular tank fitted round the top of the boiler. It is capable of shifting heavy loads, and can be started and stopped very quickly—an important qualification with shunting engines. The eight-wheel side tank passenger engine is used for working local passenger trains. It is a very handy engine, and can run, with equal facility, in either direction when working trains. It is so constructed as to be able to carry a sufficient supply of coal and water for a long day's work. There are two models at Crewe which link the present and the past in locomotive building. One is an exact fac-simile of the "Rocket" as it appeared at the Rainhill contest (the "Rocket" now in South Kensington Museum is altered from its original state), the other is a working model of the compound engine "Dreadnought." The latter has appeared at many exhibitions, and hundreds of pounds have been realized from pennies dropped in the slot, which set it in motion. The money collected in this way is always distributed to charities. Whether finality has been reached in locomotive development or not is a question time must decide, but judging from the leading record which the London and North-Western can show in railway history, it may be justly presumed that Crewe Works will still keep in advance of the motto "Never Behind" of the town by being always a step in front in the march of progress.

The following items of information show at a glance the great magnitude of this commercial undertaking. Capital, £101,000,000. Revenue per annum, £11,580,000. Expenditure per annum, £6,229,000. Number of persons employed by Company, 60,000. Number of persons employed in locomotive department, 18,000. Miles operated on, 2,700; engines owned, 2,620; carriages owned, 6,000; wagons owned, 57,000; carts, 3,500; horses, 3,500; steamships, 20. Passengers carried annually, 63,000,000; weight of tickets issued annually, 50 tons; tons of goods and minerals carried annually, 37,500,000. Number of stations, 800; signal



"JEANIE DEANS" (COMPOUND EXPRESS PASSENGER ENGINE). SEVEN FEET ONE INCH DRIVING WHEELS. SHOWN AT EDINBURGH EXHIBITION.



"GREATER BRITAIN." EIGHT-WHEELED COMPOUND (EXPRESS PASSENGER) ENGINE, 1891. DRIVING WHEELS SEVEN FEET ONE INCH.

cabins, 1,500; signal levers in use, 32,000; signal lamps lighted every night, 17,000. Value of work done at Crewe for various departments, £650,000; mileage per annum, 61,417,483; fuel consumed, 1,129,612 tons; water used, 8,416,000 tons; number of special trains run—passengers, 56,000; goods, 155,000.

Crewe provides for the whole line. All the 18,000 men in the locomotive department are under the locomotive superintendent; of these about 10,000 are drivers, firemen, cleaners, and mechanics, at the various steam sheds on the line. These are divided between the southern and northern divisions, Crewe being the dividing line. Mr. A. L. Mumford is the head of the "running" department for the southern, and Mr. G. Whale for the northern division; they are responsible for everything connected with the working of trains so far as the locomotive department is concerned, and with Mr. Earl, the manager of the works, Mr. Thompson, the signal superintendent, and Mr. Adamson, the outdoor superintendent of stationary engines, hydraulic, and water-works, are the principal assistants to Mr. Webb. There are thirty-five "steam sheds" on various parts of the lines in which the locomotives are stabled, and all their many requirements while in active service attended to. There are also repairing shops at Longsight, Carlisle, Rugby, and Willesden; these all receive the material they use from Crewe Works. The iron-work for the carriages made at Wolverton, and for the wagons made at Earlstown, is also manufactured at Crewe.

CHAPTER II.

THE MIDLAND RAILWAY WORKS AT DERBY.

By CHARLES HENRY JONES,
Assistant Locomotive Superintendent of the Midland Railway (Southern Division).

IN 1844 the Midland Counties from Derby to Nottingham and Rugby, and the North Midland from Leeds to Derby, amalgamated with the Birmingham and Derby, and became the Midland Railway. By the construction of new lines and the absorption of others the Midland has since spread out in every direction. Its main arteries connect Carlisle, Liverpool, and Manchester with London, York with Bristol and Bournemouth, and Swansea with Lynn, while its branches place it in communication with most of the important towns in the kingdom.

The Company's head-quarters are at Derby, where all the principal workshops and offices are concentrated. Adjoining the station are large blocks of offices occupied by the General Manager, Secretary, Accountant, Superintendent of the Line, Goods Manager, Mineral Manager, and the Engineer. The Directors, too, have their boardroom at Derby, and the shareholders assemble there every half-year to hear their Chairman give an account of his stewardship. There is also the Midland Railway Literary Institute, a handsome and commodious building, with a lecture-room to seat 500 persons, well-stocked library, large reading and billiard-rooms; besides class-rooms, committee and coffee-rooms. Near the station are the Locomotive and Carriage Factories, General Stores, Midland Company's Gas Works, and the workshops connected with the Telegraph and Signal Departments. The Locomotive and Carriage Works, which were formerly united, are now separate establishments. The rapid expansion of these is shown by the following figures; they afford a striking illustration of the growth of the line:—

1844.	Ground Area. Acres.	Covere. Area Acres.
Locomotive and Carriage Works	$8\frac{1}{2}$	$2\frac{1}{2}$

1891.	Ground Area. Acres.	Covered Area. Acres.
Locomotive Works	80	$12\frac{1}{2}$
Carriage ,,	86	24
Total ...	166	$36\frac{1}{2}$

Some idea, too, may be formed of the amount of work carried out in these two establishments when it is understood that in them is built and repaired the great bulk of the rolling stock owned by the Company, which comprises 2,328 engines, 4,586 carriages, 110,752 wagons. If these were marshalled in a continuous line close coupled, they would form a passenger train thirty-six miles long with six and a half miles of engines, and a goods train 391 miles long with thirteen and a half miles of engines, or altogether one train 427 miles long, including twenty miles of engines, which would reach from London to Edinburgh.

The Locomotive Department is now presided over by Mr. S. W. Johnson, who is in command of an army of 13,150 men. About 4,250 of these are at Derby, and the remaining 8,900 are engine-drivers, firemen, cleaners, mechanics, &c., stationed at eighty other Locomotive Depôts. Some of these Depôts accommodate as many as 120 to 130 locomotives, and have large workshops attached to them, while others afford shelter for only one engine. Under the supervision of the chief of the Locomotive Department there are at the present time 2,328 locomotives, 302 stationary engines, 267 stationary boilers, 1,023 hydraulic machines, 416 cranes of every kind, and all the turntables, water columns, pumping plant, and other mechanical appliances throughout the system. He also controls the manufacture and distribution of gas, the fire brigades, and the maintenance of the weighing machines. It will be seen that the office of Locomotive Superintendent is no sinecure. He is aided in the administration of his department by a Works Manager, two Assistant Superintendents (one over the Southern and the other over the Northern Division), thirty-three District Superintendents, a Secretary, Gas Engineer, and other officers.

The Works at Derby are entered through the chief offices of the Locomotive Department. Twenty-two stationary engines, total 2,400 horse-power, drive the machinery in the workshops. On the average forty new engines are built in the works every year, 120 rebuilt with new boilers, and from 750 to 800 undergo heavy repairs. An engine will run eighteen months or two years with slight repairs. A boiler, which is the most costly item, lasts on an average fifteen years, or it would probably be worn out after the engine had run 35,000 to 50,000 miles. In the offices 120 clerks are busy conducting the general correspondence, adding up wages, making innumerable returns of miles run, fuel and stores consumed by the locomotives, and keeping records of all materials used and repairs done. Twenty draughtsmen are engaged in preparing plans, designing machinery, and making drawings and tracings for the workmen in the factory. In the laboratory a chemist and two assistants are constantly employed in testing metals, analyzing water, and conducting a variety of experiments to ascertain that the stores purchased by the Company are of the quality specified in the tenders. In the testing room samples of metal cut from boiler plates, wheels, tyres, axles, copper plates, brass tubes, &c., are subjected to severe mechanical tests to gauge their quality. The machinery used for the purpose will exert a power of 100 tons per square inch, and the result, whether it be tension, compression, torsion or bending can be measured to one ten thousandth part of an inch. The samples after testing are carefully arranged and classified in glass cases, with their fractures exposed to view ; a complete record is kept of all, so that the character of material supplied by the different manufacturers is always known. In the photographic studio, which is now an indispensable adjunct to large works, three artists are regularly employed photographing engines, machinery, tracings, and drawings. The photographers are now specially busy taking views of the scenery and places of interest on the Midland route for the adornment of the carriages. Near the offices is the fire brigade station, where a "Merryweather" steamer, which will throw 600 gallons per minute, is always in readiness to be despatched on a specially constructed truck to any place where a fire may break out upon the Company's premises. In a siding hard by is the breakdown train fully equipped with lifting tackle and all the necessary appliances to cope with a railway accident. Similar provision against fire and accident is made at other principal stations on the line.

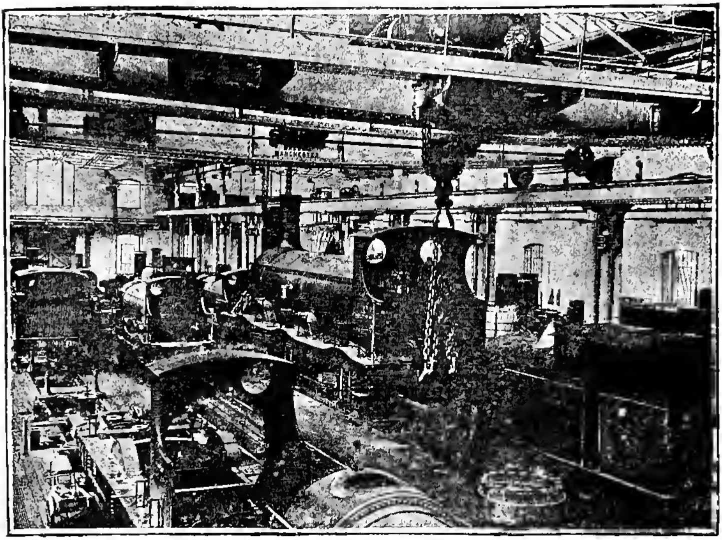
Three large mess-rooms are provided for men who cannot go home for their meals. One, where smoking is allowed, will seat 800 men; another, in which it is forbidden, 800; the third, where religious services are held during breakfast, will accommodate 400. Each room has its own cooking apparatus, and the cooks always appear in clean white caps and aprons. It is often a matter of surprise to visitors to the works to learn that the men seldom have any trouble in claiming their provisions which they bring from home; the difficulty is easily got over by each man adopting some particular device by which he is able to recognize his own dish.

The Forge is seen to best advantage after dark. Smiths with their characteristic fisher caps and leather aprons are grouped round fifty glowing fires, while strikers, with sleeves tucked up, are swinging heavy hammers, which they bring down with unerring precision on the heated iron as the smith turns it about on the anvil. Down the centre of the shop are several steam hammers, the largest of which is capable of striking a blow of seven tons or cracking a nut without injuring the kernel. Scrap iron collected in the factory is worked up under this hammer. It is cut cold by huge shears into small pieces, which are cleaned by being rubbed against each other in revolving cylinders, then piled up on square boards in heaps of about 180 lbs. weight, laid in the furnace and heated into "blooms." These are pounded under the big hammer into "uses" or rough forgings of connecting and coupling rods, eccentric rod feet, cross heads, &c. About eleven tons weekly of finished forgings are made by the hammer. The shears which cut the scrap will snip a piece of cold iron three inches thick and five inches wide as readily as one might cut an apple with a pocket knife. The other steam hammers are largely used in stamping, out of wrought iron, spanners, draw bar hooks, and numerous other articles which were formerly forged by hand. A few blows squeeze them into shape between steel dies on the hammer and anvil blocks.

In the Spring Shop skilled men are at work bending and tempering steel plates, and setting them up into springs fastened together with wrought iron hoops. The importance of having springs carefully made, tested, and adjusted will be understood when it is borne in mind that upon them depends the smooth running of engines and tenders, which together weigh from seventy to eighty tons. The springs must be sufficiently elastic to counteract all the irregularities of the road, aggravated, it may be, by a speed of sixty or seventy miles per hour. The hoops or buckles expanded by heat are shrunk on to the springs by rapid cooling until they grip them with a grasp of many tons. It used to take repeated blows of heavy hammers to remove buckles when springs were pulled to pieces for repairs; by the aid of hydraulic power they are now drawn off as easily as a lady takes off her glove; a vast amount of hard manual labour is thus saved without injury to the plates and buckles. Four hundred engine and tender springs are repaired weekly exclusive of new work.

The Iron Foundry is served by four cupolas, two of which are constantly in use. The pig or scrap iron, coke, &c. are carried up to a stage 20 ft. above the ground floor by a hydraulic hoist and tumbled into the mouth of the furnace. Under the influence of a strong blast of air all this is soon reduced to a seething mass of molten liquid. The pure metal falls to the bottom to be drawn off as required for use in the foundry, impurities rise to the surface and are run out from time to time. A fully-charged cupola holds about five tons of iron, ten cwts. of coke, and a small quantity of limestone. In the Foundry are a twenty-ton overhead travelling crane and three hydraulic five-ton cranes, which swing huge ladles of red-hot metal from the furnace to the different moulds. The whole shop floor is covered with loose black sand. Red-hot metal castings, wooden patterns and moulding boxes lie in all directions. The steam and noise is somewhat bewildering to a stranger, but, notwithstanding the apparent confusion, every man knows his own particular duty.

Let us stop and examine more minutely what is being done. Kneeling on the floor is a man with an iron box in front of him. He partly fills the box with sand from the floor, and inside lays a wooden pattern of an eccentric strap or some other article; adding more sand, he presses it tightly round the pattern until the

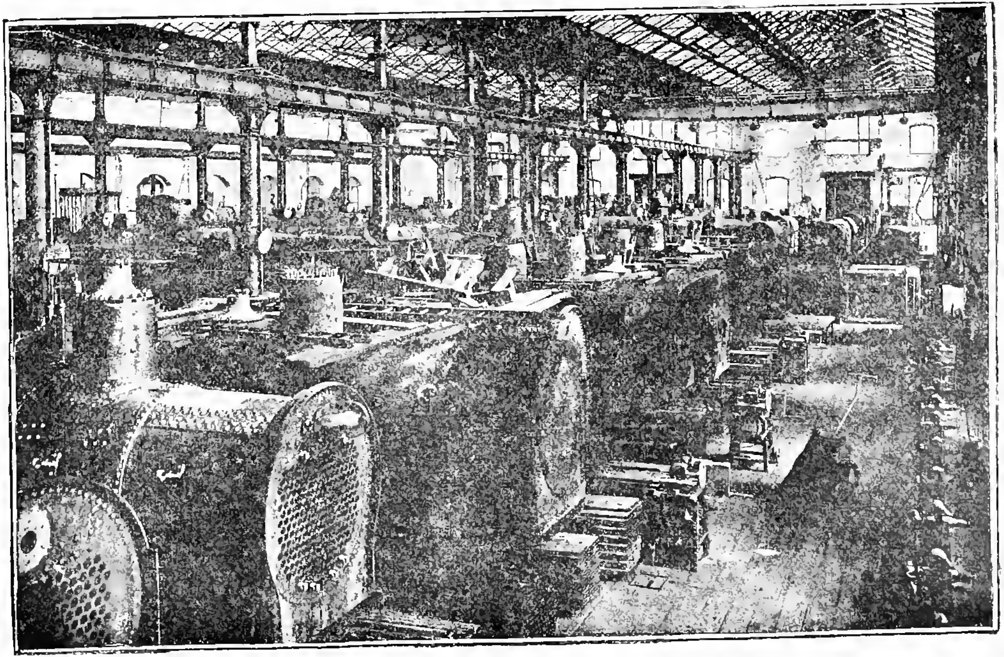


TWO 20-TON OVERHEAD TRAVELLING CRANES LIFTING A LOCOMOTIVE

box is quite full, then gently withdrawing the model, it leaves its impression in the sand. The lid is filled in like manner, fixed on the top of the box; and a hole is scooped out to admit the metal; soon two men make their appearance carrying a ladle of molten iron which they pour into the mould. When the iron has "set" the box is opened, the sand falls away, leaving a casting of the exact form of the wooden model. In this way are produced cylinders, water-pipes, lamp-posts, weighing machines, signal fittings, wheel splashers, engine chimneys, and every conceivable form of iron casting used on a railway. The castings vary in weight from sixteen tons to a few ounces. The weekly output averages 100 tons. Engine firebars and brake blocks are in constant demand, and are made in special machines at considerably less cost than by hand. The firebars are cast with their face downwards on a chilled plate, to insure that when in use the purest and strongest iron will be in contact with the fire. In the foundry is a machine for moulding toothed wheels without the use of wooden models. It is a most accommodating tool, dealing with bevel, spur, mitre, worm or helical teeth with equal facility, varying to any extent the size of teeth or wheels.

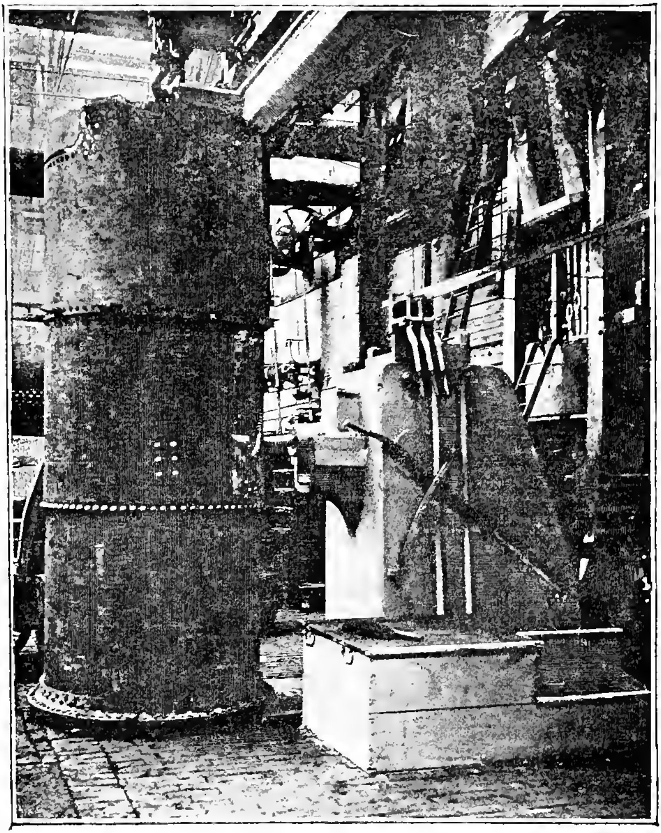
The Brass Foundry contains twenty-four furnaces below the level of the floor. The articles produced, such as water-gauges, axle brasses, lubricators, brake fittings, steam whistles, &c., being of light weight, no heavy lifting tackle is required. The crucibles in which brass is melted hold 120 lbs. each; they are readily lifted out of the furnaces and carried to the moulds by hand. Some of the brass axle-bearings are coated in this shop with a more durable white metal. A useful and interesting little machine is at work here. At the bottom of a long wooden box revolves a spindle with magnets fixed spirally round it; sweepings from the floors of the turning and fitting shops are poured through a hopper into the box, the bits of iron and steel are picked out by the magnets, and revolving brushes sweep them off into a separate tray, leaving the brass, which is of considerable value, to run out at a side aperture for re-use. Sixty men work in this shop, and twelve tons of castings are turned out weekly. The Coppersmiths', Tin, and Pattern Shops are all interesting, but space will not admit of any description of them.

In the Boiler Shop 460 men are employed. The barrel of a large new pattern boiler contains 246 copper tubes 10 ft. 6 in. long and 1¾ in. in diameter. A strong blast created by the exhaust steam from the cylinders draws the flames and hot gases from the furnace through these tubes into the chimney. When the engine is in steam all the tubes and hot copper plates of the inner fire-box are covered with water, and they together give such a large heating surface that steam is rapidly generated. When the boiler shop door is opened the din of the riveting which greets the ears is deafening. About eighty boilers and tender tanks are in various stages of construction. On one side is a long row of smiths' fires at which is done all the forging and welding in connection with the boiler work. Here are ponderous machines for shearing, punching, drilling, and flanging iron plates and planing their edges. There are, besides, rolls through which plates are repeatedly passed until they assume a cylindrical form. Looking upwards one sees a boiler barrel 4 ft. in diameter and 10 ft. 6 in. long suspended vertically from a travelling crane, which carries it across the shop to the steam riveter, as shown in the illustration. The line of holes at the junction of two plates of the



BOILER SHOP.

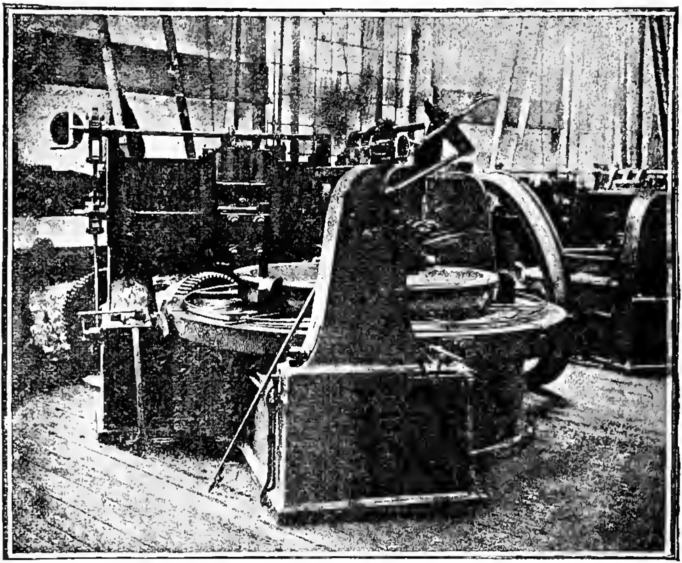
barrel is brought between the steam plunger and the



STEAM RIVETER.

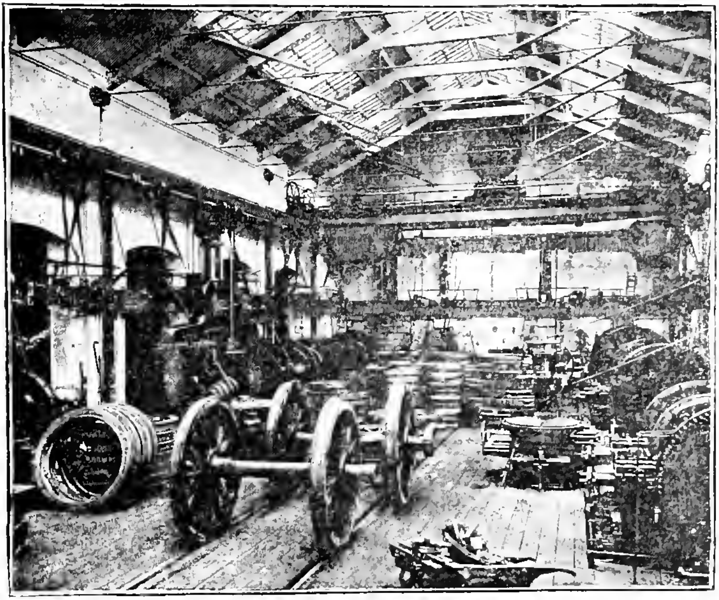
anvil; as red-hot rivets are inserted by one attendant another opens the valve and causes the plunger to dart forward to clench the rivet with a thud. One blow on each rivet is sufficient to hold the plates so tightly together that when steam is got up in the boiler at a pressure of 140 to 160 lbs. per square inch, a leakage in the joint will rarely be found. Boilers and fire-boxes are built up, the tubes put in, and all gauges, taps, and other mountings fixed; in fact they are finished in every respect and tested before leaving this shop. New boilers are tested with hydraulic pressure to 220 lbs. per square inch, also with steam to 160 lbs. After the locomotive gets into traffic the boiler is periodically examined and tested. Boilers using hard water soon get encrusted with a coat of lime, necessitating frequent repairs. To prevent this the water used in the Midland Works is now softened by a simple chemical process.

In the Turning and Press Shops, wheels, tyres, and axles, received from the makers in the rough, are finished and put together by some of the most powerful machines in the works. A rough forging of a steel crank axle weighing 1 ton 8 cwts. revolves slowly in a big lathe, while seven tools pare down and round its surface. It has to be slotted, planed, drilled, and turned again before it is finished; its weight will then have been reduced by half-a-ton. Besides several machines for centring and turning axles, cutting key-ways in axles, and turning, facing, and boring wheels and tyres, also numerous lathes and slotting machines, there are here mills for boring wheel tyres similar to the one shown in illustration. A tyre is laid on a round iron table; by turning a screw three cramps, working in radial grooves, close simultaneously, grip the tyre, and fix it exactly in a central position on the table. The mill is then set in motion; as the table revolves, three tools in slide-rests turn the inside of the tyre to the standard dimensions and cut the "lip" which helps to secure it to the wheel.



TYRE-BORING MACHINE.

In an adjoining shop is performed the operation of shrinking tyres on wheels. The furnace door is lifted, and a hot tyre 7 ft. 6 in. in diameter is dragged out of the flames to a "bosh" or circular iron trough let into the floor; a pair of wheels, complete except the tyre, and fixed on an axle, is suspended from an overhead crane, one wheel over the other; and lowered until the bottom wheel drops inside the heated tyre, which is then slightly cooled by water. Before heating the tyre is a shade smaller than the rim of the wheel, but the



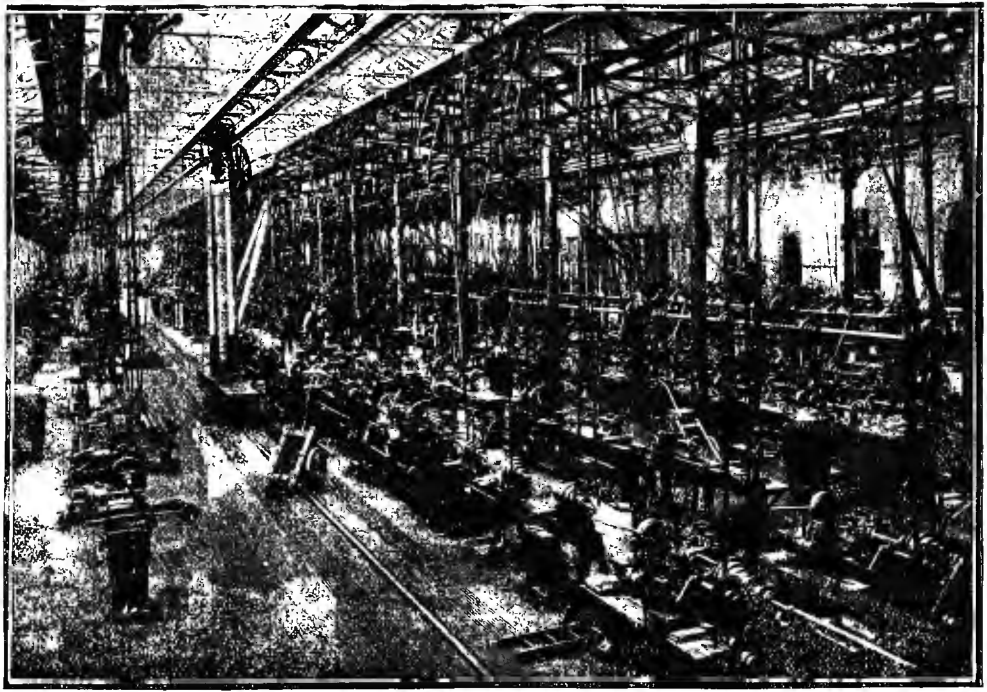
WHEEL SHOP.

heat expands it sufficiently to admit the wheel, and the contraction whilst cooling shrinks it tightly on. Some very unpretending hydraulic machines in this shop are quietly pressing wheels on and off their axles, each exerting a force of 500 tons.

The Machine, Erecting, Paint, and Millwrights' Shops are all under one roof; the whole building is 450 feet square, and is one of the recent additions to the works.

In the Machine Shop are over 400 machines capable of accomplishing almost everything which human ingenuity has devised in the way of cutting and shaping metals. Boring tools slowly worm their way through locomotive cylinders, eighteen inches in diameter, and skim the inner surface as smooth as writing-paper. Steel plates, twenty to twenty-five feet long, three feet wide, and one inch thick, lie, seven deep, on the tables of slotting and drilling machines, while several tools, operating together, shape them into engine frames and pierce them with hundreds of bolt-holes. Walking cranes promenade the shop, stopping here and there to pick up rough castings and forgings, some three tons weight, and placing them gently on the machines, or remove the finished articles. The "sand blast" is at work here, sharpening blunted cutting edges of fitters' files at the rate of six or seven dozen per day. To ensure accuracy and uniformity of workmanship hundreds of steel gauges which will measure to the ten-thousandth part of an inch are provided for the fitters and machinists.

In the Erecting Shop are nine lines of rails running throughout the 450 feet length; on each line is standing room for twelve engines, so that the building accommodates 108 locomotives. Cranes, capable of carrying an engine bodily to any part of the shop, run on gantrys overhead. The method of driving the cranes is a remarkable example of the conversion of speed into

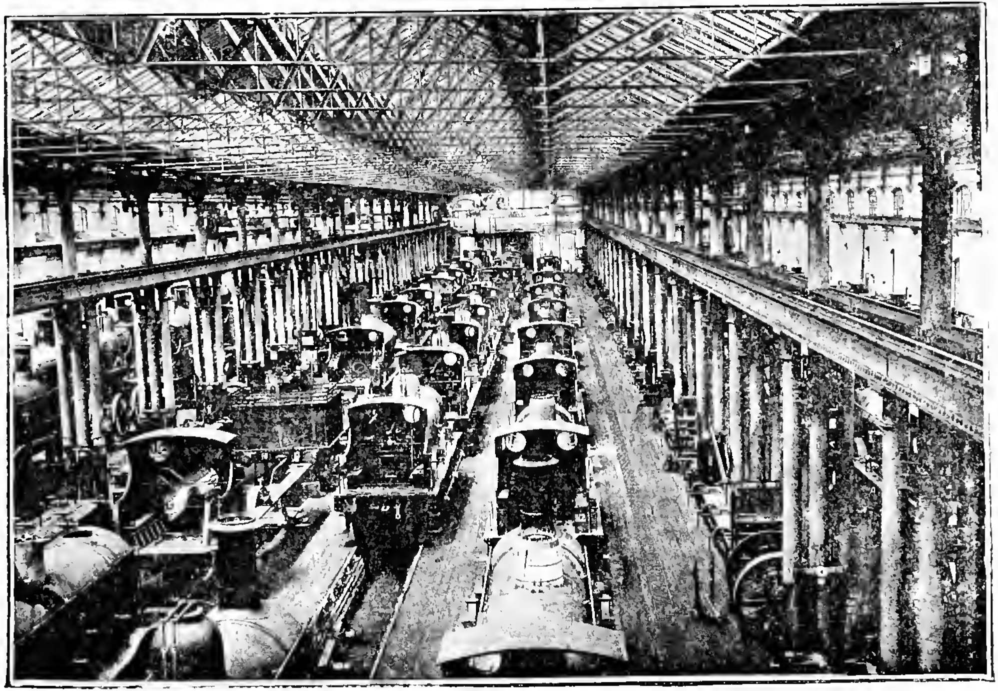


MACHINE SHOP, SHOWING TRAVELLING CRANE.

power; a rope only one inch thick running at 2000 feet per minute lifts a weight of twenty-five tons. All the component parts of an engine, which we have seen in process of manufacture, are brought to the Erecting Shop to be built up into the complete locomotive. Frames, cylinders, and cross-stays are bolted together and the accuracy of their adjustment tested by careful measurements. The finished boiler is then lowered into position between the frames, the foot-plates and weather screens fixed, the valve motion put up, and the wheels rolled under the frame. All that is then required is to fix the outside lagging and paint the engine, after which it is ready for traffic. Usually a gang of four men and two boys work together at each engine; it takes about three weeks to erect it. All labour is paid for by piece-work. The leading hand of each gang contracts to build the engine (labour only) at a given price. During the progress of the work he and his assistants receive stated weekly wages; when finished, the balance is equitably divided.

In the Paint Shop thirty or forty locomotives are being made spick and span with four coats of paint and three of varnish ready to appear in public. Formerly green was the distinctive colour of Midland engines, but now they are reddish-brown to match the carriages. They require painting every three or four years, and between 600 and 700 annually undergo that process.

In the Millwrights' Shop an endless variety of work is done. Scattered over the floor are electric light and hydraulic engines, travelling cranes, sewing-machines for wagon sheets, chaff-cutters, warehouse cranes, capstans,



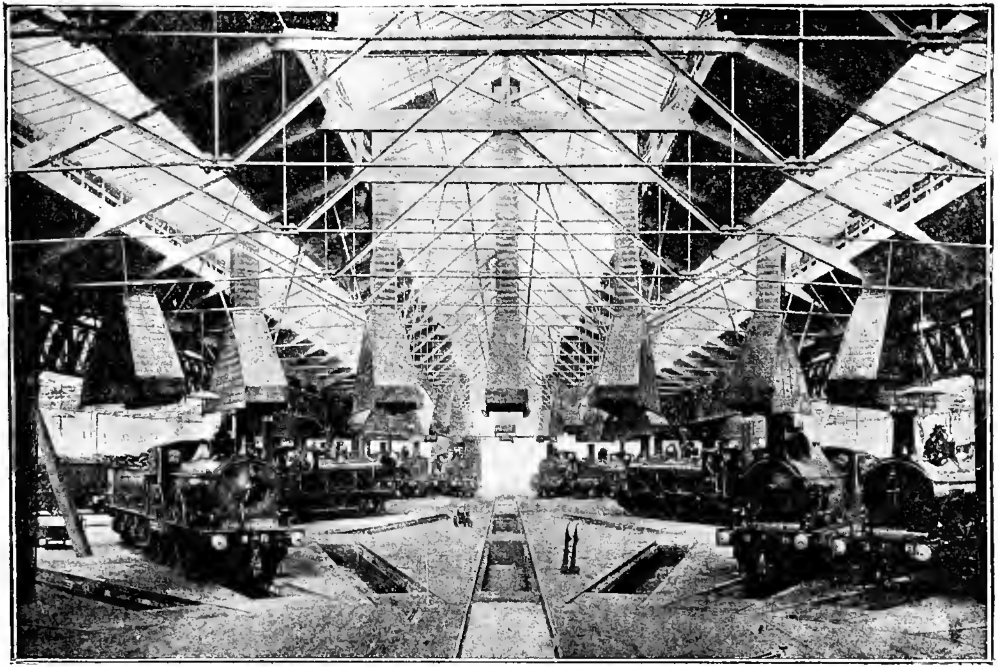
ERECTING SHOP.

turntables, water tanks, &c., &c., all in course of construction or under repairs. The millwrights execute all repairs to the machinery and shafting throughout the line.

Some years ago the Midland Company acquired the original Derby Gas Works, adjacent to the station, from which, in 1892, 119,132,000 cubic feet of gas were supplied to the Company's works, station, offices, sidings, and all the signals in the neighbourhood.

There are four Running Sheds at Derby, and 150 locomotives are stabled in them. The one which is the subject of our illustration holds forty-eight engines; there are two turntables in it, and around each radiate twenty-four pits over which the engines stand on rails whilst they are cleaned and steam is got up. Drivers and firemen are coming to or leaving their work at every hour during the day and night. After signing on duty they take in coal and water, oil their engines, and then join their trains. When booking off duty the driver enters on his "sheet" the quantity of coal, oil, and waste with which he was supplied, and the miles he has run. He also reports repairs required to his engine, and any unusual circumstance that may have happened on the journey. There are 2,833 locomotive drivers, 2,557 firemen, and 1,340 cleaners in the service, exclusive of numerous steam-risers, boiler-washers, gland-packers, bar-boys, and labourers connected with the running sheds.

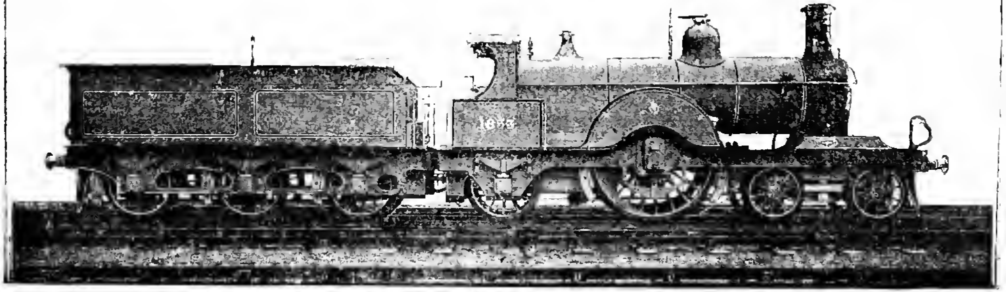
The types of locomotives on any line should be as few as possible, and the parts interchangeable, as in case of the failure of an engine at any place, the defective



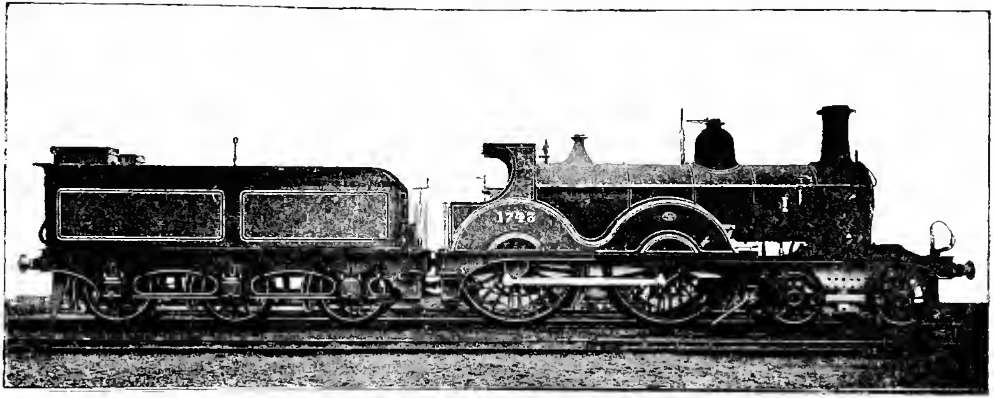
ENGINE STABLE OR RUNNING SHED.

fittings require to be renewed from head-quarters without delay. Besides, engines are constructed more cheaply and expeditiously, when the same drawings and models are used, and when the workmen are constantly engaged repeating the same articles and putting them together without special fitting. The standard types on the Midland are shown in the illustrations.

The express passenger engine No. 1,853 was exhibited in the Paris Exhibition, 1889, and its designer, Mr. Johnson, obtained the Grand Prix. This engine has a single pair of driving wheels and a bogie in front; it was specially constructed for the express service between London, Nottingham, and Leeds, booked at fifty-three and a half miles per hour, with loads of from nine to thirteen coaches. Engines of this class have been performing the work for several years with an average consumption of twenty to twenty-three lbs. of Derbyshire coal per mile; they have frequently taken from thirteen to sixteen coaches. In their design economy of fuel, and steadiness and facility of working, have been considered of most importance, so that the attention of drivers and firemen may be distracted as little as possible from the performance of their duties. The engines are fitted with automatic steam and vacuum brakes, also with steam-sanding apparatus, which in a great measure overcomes the tendency sometimes found with "single" engines to slip on a greasy rail. They are provided with an automatic sight feed lubricator, which enables the driver to see what quantity of oil is being used, as it rises through a glass tube drop by drop on its way to lubricate the valves and cylinders.



SINGLE-WHEEL EXPRESS BOGIE PASSENGER ENGINE.



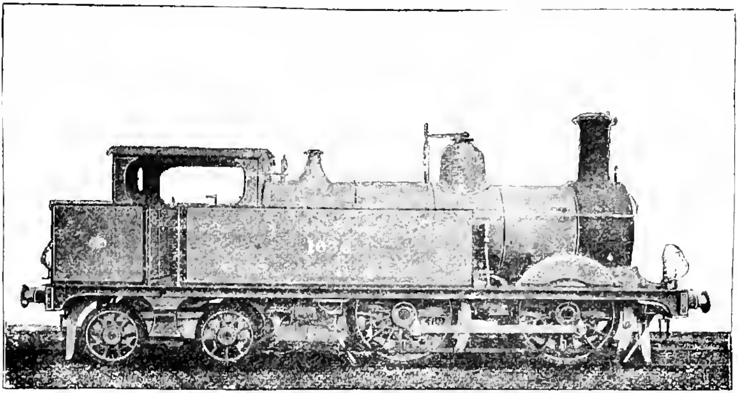
FOUR-WHEELED COUPLED EXPRESS BOGIE PASSENGER ENGINE.

The following are the leading dimensions of the engine :—

Diameter of cylinders	18½ in.
Length of stroke	26 ,,
Diameter of driving wheels	7 ft. 6 ,,
Total length over buffers	52 ,, 0 ,,
Working pressure of steam	160 lbs. per sq. in.
Grate area	19½ sq. ft.
Tubes	242 ea. 1⅝ in. diameter.
Heating surface, tubes	1,123 sq. ft.
,, ,, fire-box	117 ,,
Total	1,240 ,,
Weight in working order, engine	43 tons.
,, ,, ,, tender	35 ,,
Total	78 ,,
Weight on driving wheels	17½ tons.
Water capacity of tender	3,250 galls.
Coal	3½ tons.

The four-wheeled coupled bogie tender engine No. 1,743 has eighteen inch cylinders, twenty-six inch stroke, driving and trailing wheels seven feet diameter, boiler pressure 160 lbs. per square inch; the tender carries 3,250 gallons of water and three and a half tons of coal. It is a representative of the type of engines which do the heaviest passenger work on the main line. They are daily running between London, Leicester, and Leeds, with from twelve to twenty vehicles, at a booked speed of fifty miles per hour. An engine of this class obtained for Mr. Johnson the gold medal at Saltaire in 1887. It has the honour of being called after Princess Beatrice, who opened the exhibition, and is the only engine on the line which is distinguished by a name; the rest are known by their numbers. The "Beatrice" took her Majesty from Derby on her way to Scotland in May 1891.

The four-wheeled coupled bogie passenger tank engines, of which No. 1,636 is an example, have eighteen inch cylinders, twenty-four inch stroke, leading and driving wheels five feet three inches in diameter; they carry 950 gallons of water and one and a half tons

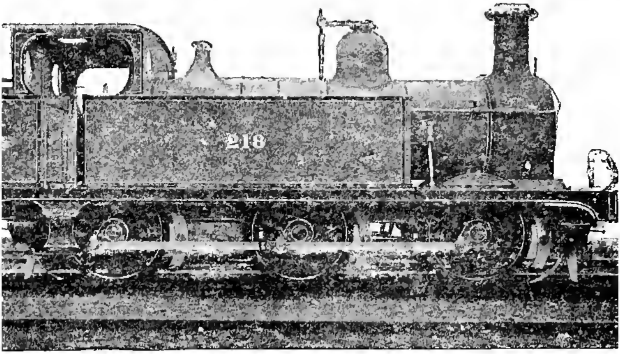


FOUR-WHEELED COUPLED BOGIE PASSENGER TANK ENGINE.

of coal. They work "shuttle" trains on branch lines where the runs are short and frequent, and there is not time for turning at the terminal stations. Similar engines fitted with apparatus for condensing exhaust steam in the tunnels work the Midland trains over the Metropolitan line.

The six-wheel coupled tender engines of No. 1,700 class have eighteen inch cylinders, twenty-six inch stroke, wheels four feet ten inches in diameter. Their

ers hold 2,950 gallons of water and four and a hal
of coal. They are built for mineral traffic, and ar(
ble of hauling forty-five loaded coal wagons (60(
) on a moderately level road at a speed of twenty
s per hour. The standard goods engines are of th(

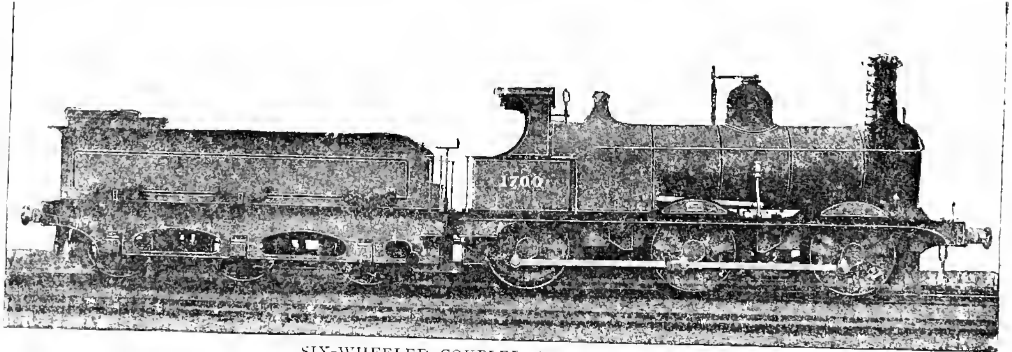


SIX-WHEELED COUPLED GOODS TANK ENGINE.

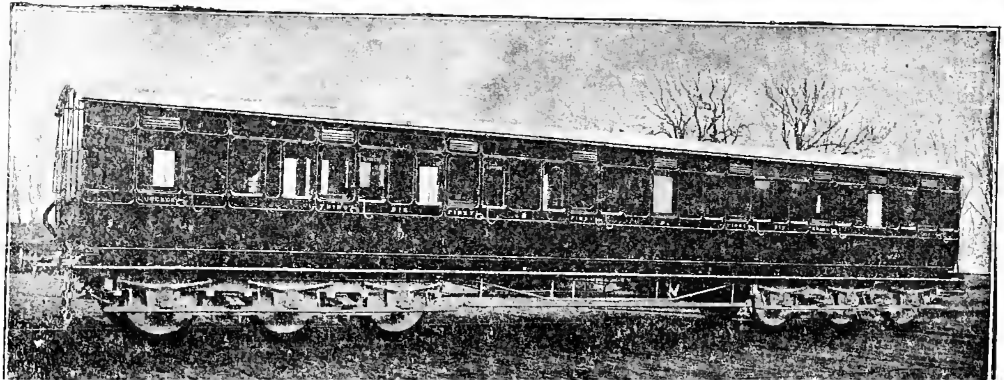
e construction, excepting that their wheels are fiv
two and a half inches diameter.

oth goods and mineral engines are fitted with th
m brake applied to all the wheels of the engine an(
ler; some of the goods engines have also the vacuur
:e, as they are frequently required in the summer
: to work heavy excursion trains.

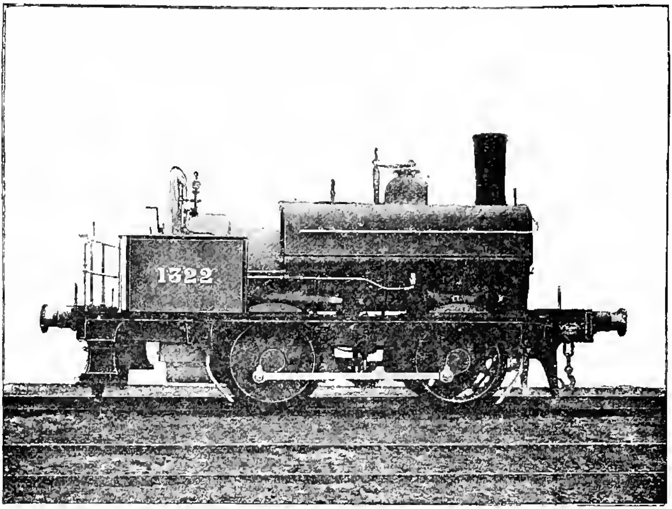
he six-wheel coupled tank engines like No. 218 hav
:nteen inch cylinders, twenty-four inch stroke, wheel



SIX-WHEELED COUPLED GOODS ENGINE.



four feet six inches diameter, wheel base fifteen feet; they carry 900 gallons of water and one and a half tons of coal. They are fitted with steam brakes, and are chiefly used for shunting purposes; they start and stop quickly and move heavy loads, essential qualifications



SMALL GOODS TANK ENGINE.

for sorting traffic with despatch. These engines also work goods and mineral traffic over branch lines which have exceptionally steep gradients.

The four-wheel tank engines of No. 1,322 class, fitted with a steam brake, have thirteen inch cylinders, twenty inch stroke, leading and driving wheels three feet nine inches diameter, carry 400 gallons of water and eight cwts. of coal. They are useful in dock and brewery yards, as the wheel base (seventeen feet) is so short that they will travel round any curve over which a wagon will pass.

The composite carriage No. 916 on two six-wheeled bogie trucks, was exhibited with engine No. 1,853 at the Paris Exhibition, 1889. It is one of the ordinary type, containing three first class, three third class, lavatory, and guard's compartments. It is fitted with automatic vacuum continuous brake and electric light. The carriage is fifty-six feet long over the body, eight feet wide, seven feet high, weighs twenty-four tons thirteen cwts., and will accommodate sixteen first class and twenty-eight third class passengers. The first class compartments in this carriage are samples of different styles adopted for the Midland Company's stock. That for ladies is upholstered in brown plush, the non-smoker's in blue woollen carriage-cloth, the smoker's in crimson morocco; the third class compartments have crimson and black linings as in the ordinary Midland carriages. In the guard's compartment is a hand-brake, a valve for applying the continuous brake, a switch for controlling the electric light, and appliances for communicating by cord with the driver. The under-frame is of oak, the floor, partitions, roof, and inside casing red deal, the outside panelling and mouldings Honduras mahogany. Bogie trucks are chiefly wrought iron, tyres and axles Bessemer steel, wheel discs of teak wood segments, the bosses cast iron. The axle-boxes are so arranged that the brass bearings can be taken out and replaced without lifting the carriage.

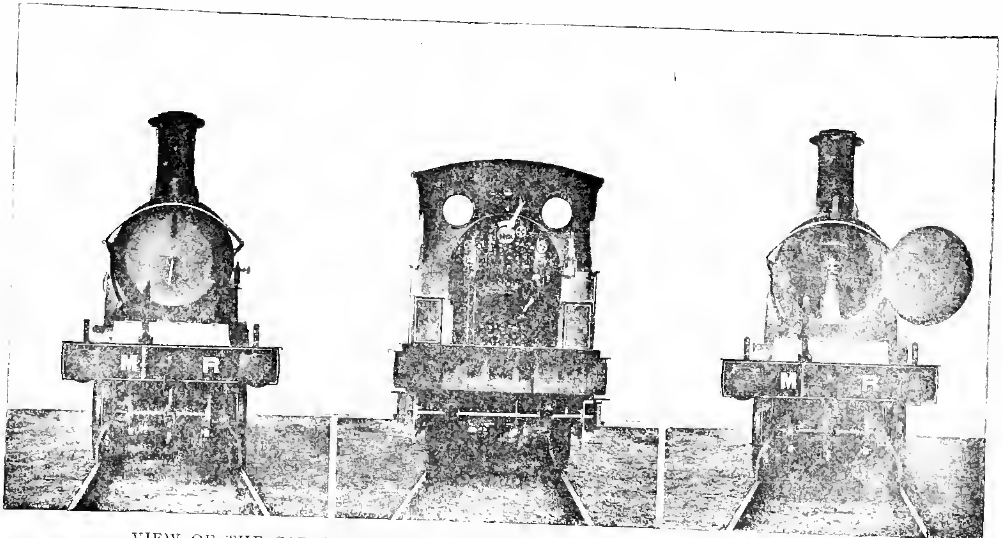
The Midland is frequently spoken of as the "Pioneer" Company, a title fairly earned by the beneficial changes in railway practice which it has initiated.

In 1872 the Midland allowed third class passengers to travel by all trains at the rate of a penny a mile; this change, inseparably connected with the name of Sir James Allport, is a great boon, especially to the working-classes.

In 1874 second class carriages were abolished in order to reduce the weight of the trains, which had become abnormally heavy through the great increase in third class passengers. A comparison of the number of passengers carried in 1874 and 1891 is striking:—

	1st Class.	2nd Class.	3rd Class.	Total.
1874	1,204,377	2,703,420	20,316,346	24,224,143
1892	1,230,688	——	37,533,455	38,764,143

In 1881 another very important change was resolved upon by the Midland Board, viz. the purchase by the Company of private owners' wagons. So long as nearly all the large traders possessed their own wagons they were of course exclusively used by them. For example, a truck loaded with coal from Derbyshire to London had to be returned empty to the colliery, but when it became the property of the Midland Company it could be loaded in a contrary direction or sent elsewhere. Formerly an immense amount of shunting was required to sort out the right wagons for the different collieries, &c., whereas when all traders are served from one common stock that is avoided. Another consideration which had great weight with the Directors was, that



VIEW OF THE CAB AND CHIMNEY ENDS OF A MIDLAND RAILWAY ENGINE.

when wagons were under the control and supervision of the Company's own officers, they could rely upon their being kept in a more efficient state of repair. The wisdom of the course adopted has been made manifest by a marked reduction in the working expenses, and a singular immunity from accidents through the breaking down of trucks in transit since the change was made.

In 1875 a trial of competitive railway brakes was made by the Royal Commissioners on Railway Accidents on the Midland line near Newark. The result was a death-blow to hand brakes. It was shown that a train travelling on a level road at forty-five miles per hour could not with the ordinary hand brakes be stopped in less than 800 or 1000 yards, whilst any good continuous brake would stop it in one-third that distance. Since that time the whole of the Midland passenger stock has been fitted with the continuous brake. The system adopted is a steam brake on the engine and tender, combined with the automatic vacuum on the carriages. One movement of the handle on the engine or in the guard's van applies both brakes simultaneously.

Dining-Room and Sleeping Cars and Lavatory Carriages have been introduced; many of the trains are lighted with gas or electricity, and, in the hope of increasing the comfort of the passengers, the Locomotive and Carriage Superintendents are now experimenting with a new contrivance for warming the carriages in cold weather with hot water from the engine boiler. Two pipes, with suitable couplings between the vehicles, run throughout the train; the driver charges them by opening a special valve on the engine, which allows the hot water to flow down one pipe and return to the tender tank through the other. After a few minutes he slightly closes the valve, thereby reducing the supply of hot water to an exceedingly small quantity, but sufficient to keep up the circulation. No water is wasted, as, after passing into the tender, it is injected into the boiler again. Very little steam is required to maintain an even temperature throughout the train. By a simple arrangement the pipes are always emptied when the vehicles are uncoupled, so there is no chance of the water freezing in winter. Two trains fitted with this warming apparatus have been running for some time between London and Bradford ; so far the result has been satisfactory. It is to be hoped that foot-warmers will soon be relics of the past.

The following statistics will give some idea of the magnitude of the Midland Company :—

Capital	£98,833,259
Revenue per annum	£9,171,153
Expenditure ,, ...	£5,081,539
Miles operated on	1,947
Train mileage per annum	41,476,937
Engine ,, ,, ,, (including shunting) ...	56,646,625
Coal consumed (tons)	1,084,238
Number of persons employed by the Company, including 13,150 in Locomotive Department, and 5,853 in Carriage and Wagon Department	53,000
Engines owned	2,328
Carriages ,, ...	4,586
Wagons ,, ...	110,732
Carts ,, ...	4,173
Horses ,, ...	4,573
Passengers carried annually	38,764,143
Season ticket holders	48,756
Tons of goods and minerals carried annually	31,724,094
Number of stations, exclusive of those owned jointly with other Companies	550

Number of signal cabins	1,590
,, signal levers in use	17,700
Weighing machines, ranging from the 80-ton machine, which registers the weight on each pair of wheels of a locomotive, to chemists' scales which weigh to the fraction of a grain	3,600

The Midland Company is quite abreast of the times with regard to the use of electricity. About 11,000 miles of wire, 60,000 batteries, and 15,000 instruments (including nearly 1000 telephones) are used on the line for transmitting messages, working the block telegraph, and indicating whether signals which cannot be seen by the signalmen are "on" or "off," or whether the lights are burning in them. In 1891, over 12,000,000 messages passed over the Company's wires. With every desire to afford a good and pleasant light in its carriages, extended experiments have for some time been in operation on certain trains with the view of lighting the stock electrically. Eight trains fitted with the electric light are running daily. Three passenger stations, five large goods depôts, and three hotels are already lighted by electricity, as are also the chief offices at Derby. In the Midland Grand Hotel, London, are 1100 incandescent lamps. The Adelphi Hotel, which the Company has recently acquired in Liverpool, has been fitted throughout with telephones, 210 being in use. Each room is arranged on an inter-communication system, so that conversation can be carried on between one room and another. A telephone attendant is located on the ground floor, and has the necessary switch-boards and numbers under his complete control. In establishing this system thirty-three miles of wire were laid in the house.

The Midland Company is not unmindful of the welfare of its employés. It subscribes liberally to the Superannuation and Friendly Societies, exclusively established for them. Its annual contribution to the Friendly Society is about £15,000. The drivers, firemen, signalmen, and many of the clerks receive at stated periods handsome bonuses for good conduct or economical working. The servants of the Company and their families have the privilege of travelling as often as they please when off duty at a quarter the ordinary return fare, and once a year they may claim a free pass for any journey they may select on the system. The Company, too, has given encouragement to the St. John Ambulance movement; and 2,600 men have already qualified themselves to administer first aid in cases of accident.

CHAPTER III.

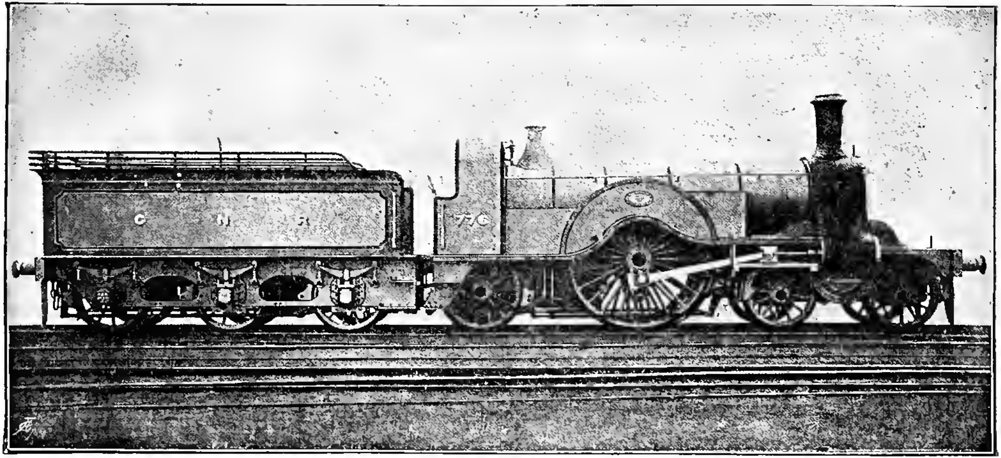
THE GREAT NORTHERN RAILWAY WORKS AT DONCASTER.

By A. J. BRICKWELL,
[Of the Surveyor's Department, King's Cross.]

TRUE to its name, the Great Northern was constructed solely to go north; and a glance at an official railway map of England will suffice to demonstrate the right of the Company to its title.

The line, authorized in 1846, is an amalgamation, in the first instance, of the London and York and Direct Northern with a loop line through Lincolnshire, later, by amalgamation, leases, &c., of numerous smaller undertakings, among which were the West Yorkshire, and Leeds, Bradford and Halifax Railways. The Company now has a system of 928 miles including joint lines.

The main line of the railway was constructed under the eminent engineer Cubitt, but before its construction was most vigorously opposed by "King" Hudson for the greater part of two sessions. It triumphed in the end, and in spite of all "his Majesty's" adverse



NO. 776, "JUBILEE CLASS," BUILT IN 1887, AND EXHIBITED AT NEWCASTLE AND EDINBURGH.

From a photograph by J. Wormald, Leeds.

prophecies the line to-day is as fine and useful a road as any in the three kingdoms.

At the first general meeting of the Company's shareholders, the number of Directors was reduced to thirty; as the line has increased the number of Directors has decreased, and the more business-like number of thirteen is sufficient for the modern mode of conducting a much larger undertaking. The Great Northern Railway is the key of three splendid routes, viz. to York and Scotland, West Riding and Yorkshire, and to Sheffield and Manchester districts. Although one may travel through without change of carriage, to reach a destination in any of the districts named, a line of another Company has to be passed over.

To reach Manchester the Company has to make use of the Manchester, Sheffield and Lincolnshire Railway, with whom at present it is very closely allied; to reach York, about thirty miles of the latter end of the journey is over the North-Eastern Railway Company's system; and to reach Leeds and the West Riding towns a piece of joint line with the Manchester, Sheffield and Lincolnshire to Wakefield must be negotiated.

Further, the Company has the right of "running powers" to Manchester, which if the new line from Sheffield to London (which the before-named Manchester, Sheffield and Lincolnshire Railway are promoting) is constructed, will doubtless be most vigorously exercised. At Godley, on the Manchester, Sheffield and Lincolnshire Railway, there is a junction with the system under the Cheshire Lines Committee, composed of the Great Northern, Midland, and Manchester, Sheffield and Lincolnshire Railways, and thus the Great Northern Railway is third owner and has the right of running to the Liverpool and Cheshire district.

The Great Northern jointly with the Midland Railway in July 1893 took over the Eastern and Midland Railway, and thus established a new district in the Eastern counties, and acquiring a substantial command of the Cromer, Yarmouth, and Norwich traffic both from London and the Midlands.

With these facilities there is fierce competition as far as the Great Northern Railway is concerned, and should the new lines from Sheffield to London and the Lancashire, Derbyshire and East Coast Railways be constructed as authorized, this competition will be strained to its utmost.

Although the Great Northern Railway has very little on its own system to offer to induce another competing company, a glance at the map will show that there is something to draw the other companies who entwine themselves about the Great Northern Railway, in an alarming manner.

Compare Doncaster Station with Crewe on the North-Western Railway, or Derby on the Midland Railway. The first has no less than five "foreign" companies using it, while the second has only one, and the last two.

At Peterborough too there may be found three "foreign" companies' engines in the Great Northern yard.

Judging from the voice of the outside public the Great Northern Railway owes the greater portion of its success to its regularity, speed, and good third class accommodation and service. A word or two about speed is worth notice, and is of special credit to the Company in question. The Great Northern and Manchester, Sheffield and Lincolnshire Railways' route to Sheffield is three and a half miles longer than that of the Midland. Comparing the best trains of both routes the Great Northern perform the journey ten minutes quicker.

To Manchester the shortest route by the London and North-Western Railway, *viâ* the Potteries and North Staffordshire, is 183½ miles, by the Midland 191 miles, while by the Great Northern and Manchester, Sheffield and Lincolnshire Railways' route it is no less than 203½; yet the Great Northern Railway does the journey in the same time, viz. four and a quarter hours. The two o'clock from London Road Station (Manchester) to King's Cross Station (London) is the fastest ordinary and daily train in the world. It should in fairness be stated the train is worked (to omit a stop at Retford) as far as Grantham by the Manchester, Sheffield and Lincolnshire Railway, but owing to that Company's difficult road, the speed does not average above forty-eight and a half miles an hour; while the last 105½ miles from Grantham to London by the Great Northern Railway engine are got over at a little over fifty-four miles an hour, the time taken being 117 minutes, including start and stop and reducing speed to fifteen miles an hour through Peterborough. This train is seldom late, and it is not uncommon for it to be one or two minutes before time.

The first class dining car system on the morning and evening trains has been actively adopted by the Great Northern Railway ; these massive vehicles weigh thirty-three tons, and are sixty-three feet six inches long. The cars are attached (for luncheon) to the 9.45 a.m. to

DINING CAR.

Leeds and 10.15 a.m. to Manchester, and (for dinner) to the 5.30 p.m. to Manchester and the 5.45 p.m. to Leeds. There are two stewards and a cook on board each car, and the stewards have the run of the King's Cross refreshment department cellar for wine, &c., till within a very few minutes of the start of the train ; while they can always fall back on the Peterborough, Grantham, Retford and Doncaster refreshment rooms for a further supply.

In the summer of 1893 the Great Northern Railway, in conjunction with its East Coast *confrères*, commenced to run Corridor Dining Car trains on the Scotch service leaving Edinburgh and London at 2.30 p.m.

With these arrangements commenced for the first time the catering for the third class passenger, who without additional fare can enjoy the comfort of dining *en route* at a very popular price.

The cars are beautifully upholstered and fitted up with hand-painted mirrors, and lighted by oil gas, which is very illuminative. The cars are divided into five compartments—lavatory, smoking-room, dining-room, steward's room and kitchen. In the winter they are heated with hot water from a stove in the steward's room. There is accommodation for eight persons in the smoking-room, twelve in the dining-room, each person having a separate seat with one table between two. The car being so heavy is carried on two "bogies" of six wheels each, making twelve in all, so that it runs very smoothly.

We now turn to the most interesting part of our story, the notorious Great Northern engine with its birthplace, Doncaster Works.

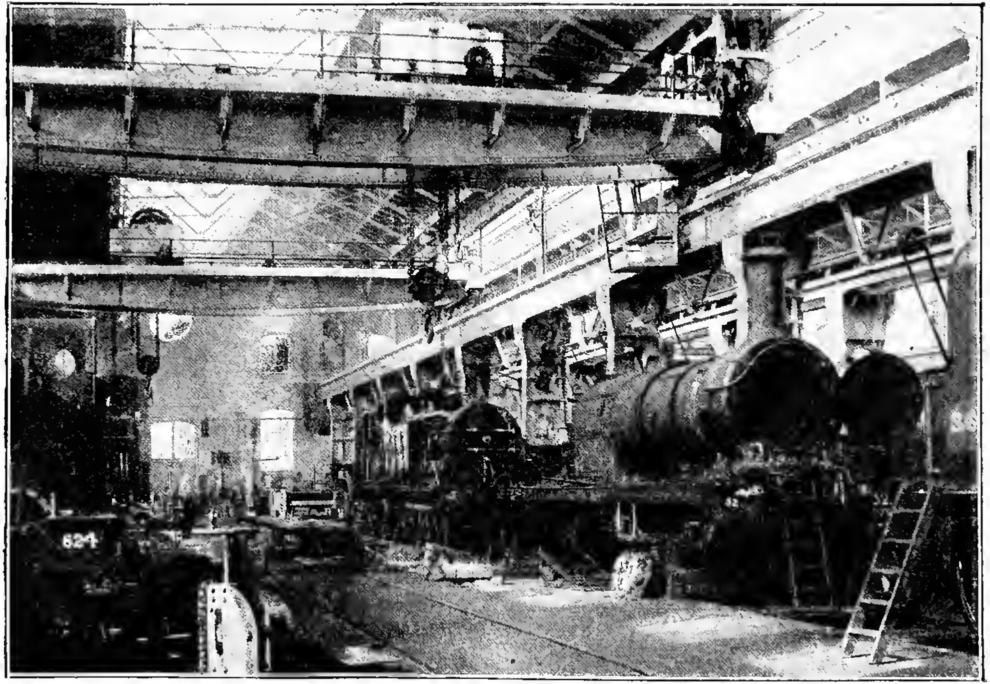
During the Doncaster Race Week the works are closed, and the sidings cleared for action. The place presents a pandemonium of railways, and to see the "foreign" railway companies' engines running into the place would naturally suggest that Doncaster Station did not belong to the Great Northern Railway Company. The whole arrangements, however, are under its immediate superintendence, which are so concise, that during the Race Week as many as 120 trains have been despatched from Doncaster in one hour.

The passenger station on this occasion is not interfered with. Excepting private specials, nothing but the ordinary service enters the station, all the excursion traffic being conducted at specially constructed sidings. Without the Great Northern Railway Company Doncaster would be a very insignificant place, its only other notoriety beyond the races and the railway, being butterscotch, of which one firm disposes of the extraordinary quantity of fourteen tons during Race Week.

On entering Doncaster from London, the works are on the left-hand side, and commence about two miles from the station, extending a little way beyond it northwards. The area covered by the works, station, and sidings is something like 170 acres, with shed accommodation for ninety-six engines.

Doncaster, like all other large engine-erecting centres, has its numerous shops, foundries, &c., which to fully explain would be only to repeat what has been copiously dealt with in previous articles upon other companies' engines.

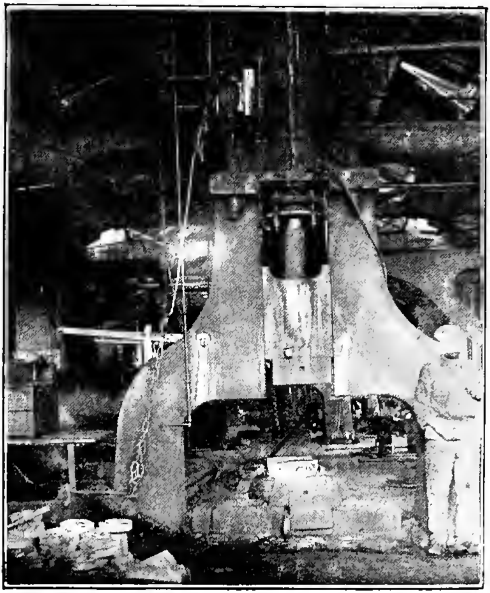
The works are reached by a footbridge over the railway, which when passed we begin to hear at once the rumble of the machinery in the adjacent shops. The number of men employed in the Locomotive, Carriage, and Wagon Shops is somewhere about 3,500, and there are about 1,000 different machines used. In 1891, 300



ERECTING SHOP.

engines, 3,735 carriages, and 15,226 wagons passed through these shops; while 99 engines, 181 carriages, and 1,493 wagons were erected as new stock or in place of old.

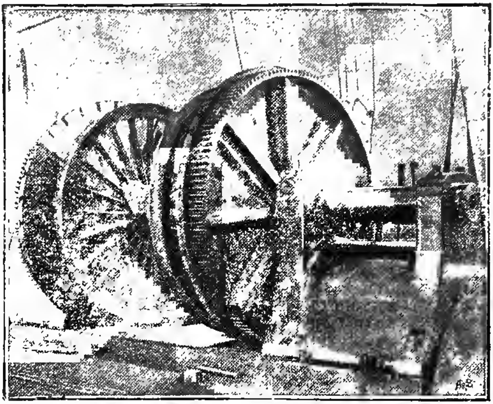
One feature is the splendid modern Erecting Shop,



STEAM HAMMER.

which was built in 1890. The shop, which has a very clean appearance, is divided into three parts, the two outside being used for erecting; while the middle is reserved for machinery used in locomotive erection. The overhead travelling cranes which may be observed at the top are capable of lifting thirty tons each, or a total of sixty tons. Each crane is controlled by one man, and can be worked into position to the fraction of an inch. On the right is a London suburban engine, No. 933, nearing completion.

Near the Erecting Shops are the steam hammers. An illustration shows a specimen capable of forcing a blow



WHEEL LATHE.

ordinarily equal to a weight of six tons, and the piece of metal directly under the hammer—though measuring not more than fifteen inches in diameter—is about to be converted into an engine connecting rod about five feet long.

One can hardly imagine a lathe capable of turning the large driving wheels of a locomotive, and the one illustrated is reputed to be the largest used for this purpose in the country, for the simple reason, that there are no larger wheeled engines than the Great Northern Railway's. This massive machine was built for the Company in 1891, and the pair of wheels shown in the illustration belong to engine No. 777, known in the service as being one of the "Jubilee Class," from the fact of their being

THE COKE-BREAKER.

built in that year. The lathe is capable of turning a wheel nine feet in diameter.

Mr. Stirling, the locomotive engineer, has introduced a very economical machine for coke-breaking. Originally, every smith before he commenced work had to break up his own coke, which being done three times a day took each man on an average altogether about one and a half hours per day. By the coke-breaker, two men are constantly employed in feeding the machine, and carting the milled coke away to the different smiths' fires, and in this way about thirteen to fifteen tons of coke are broken up every day.

As before stated, the Company's works commence about two miles from Doncaster, and here have been erected large shops for the exclusive erection of wagons. The shops are built on the most modern principle, and are fitted with electric light. A special train runs night and morning for the use of the men employed in them.

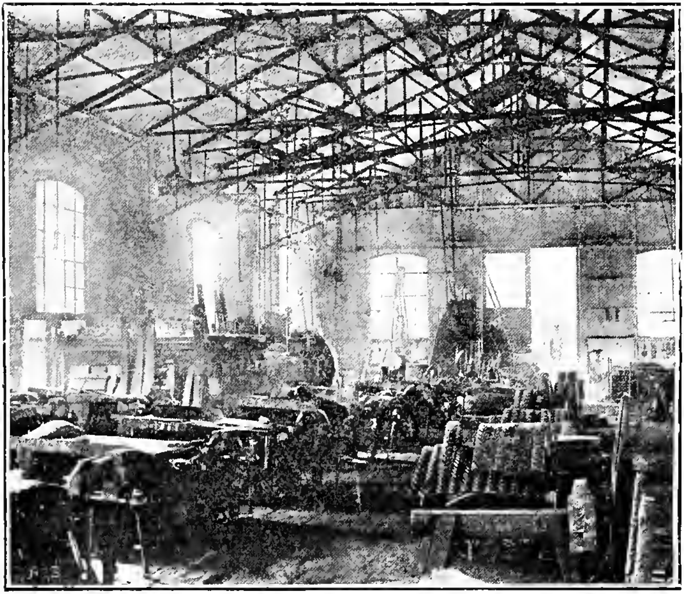
Two more places of interest are the Spring Smiths' and Boiler Shops.

Next to Doncaster in importance is Peterborough, with shed accommodation for 106 engines. At New England, a suburb of the city of Peterborough, are situated the Locomotive Works and sheds. The large shops at New England are not used for building engines, but are capable of thoroughly repairing them. Here the Company is the owner of 227 cottages and two large schools (one recently erected for boys), leaving the one first erected for the exclusive education of girls.

Peterborough is the great exchange station of the coal traffic for the Great Eastern Railway's system, and the Great Northern Railway has about twenty-six miles of siding laid down in the Peterborough and New England yards.

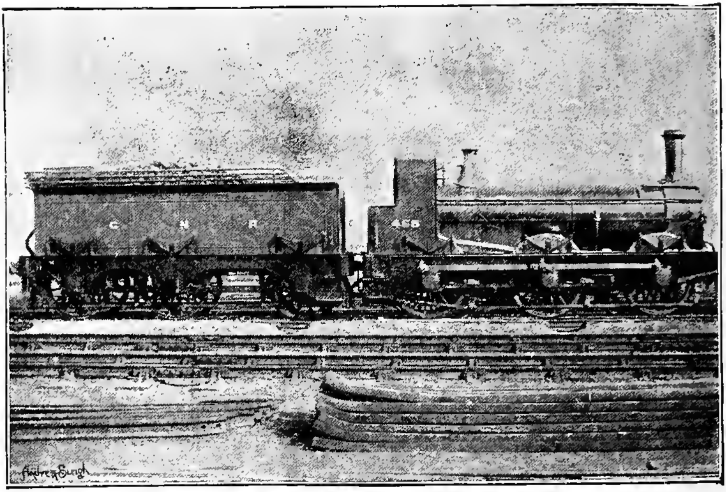
There are also large engineers' works at Peterborough for the maintenance of the line of railway and stations, with an iron foundry for casting the chairs for the rails.

Most railways are the owners or lessees of some navigation or other, and in this respect the Great Northern Railway has the control of the Nottingham and Grantham Canal, and also the River Witham and Fossdyke navigations.



SPRING SHOP.

We will now divert our attention to the Great Northern Railway locomotives themselves. No. 458 is of the old type of goods engine. It is six-wheel coupled with outside connecting rods; the diameter of the cylinder is seventeen and a half inches and twenty-four inch stroke, built in 1866, and the engine without the tender weighs thirty-eight tons. The automatic vacuum brake has only recently been fitted on this class of engine, as it was thought they would all be broken up before the brake became general on goods engines. This class of engine, which has done excellent service, is mostly used

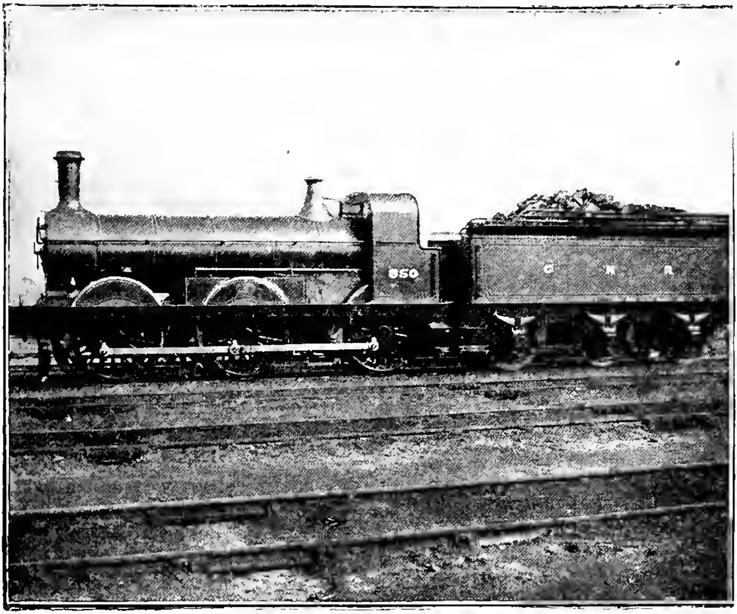


ENGINE NO. 458, BUILT IN 1866.

for slow goods traffic. The next illustration of the modern six-wheel coupled goods engine will display at once the neatness of modern locomotives. No. 850, built in 1892, has seventeen and a half inch cylinders and a stroke of twenty-six inches, and the entire weight of engine and tender in working order is a little under seventy-eight tons. This engine, like all the Great

Northern modern goods engines, is fitted with the automatic vacuum continuous brake, a great improvement on the old hand brake in more ways than one.

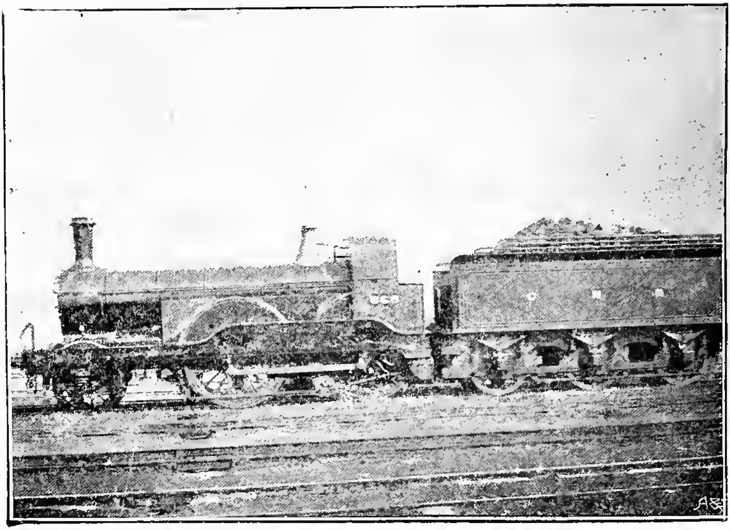
No. 868, four-wheel coupled, seventeen and a half



ENGINE NO. 850, BUILT IN 1892.

inch cylinders and twenty-six inch stroke, built in 1892, engine and tender weigh in working order seventy-nine tons. They can run anything with equal aptitude from a "parish dust" to a "royal" train, and will be found hauling both express and slow passenger, and on the Leeds and Manchester express goods trains. The latter are very difficult to work on account of their great weight and speed, it being a well-known fact that these goods trains are run at a greater speed than some southern lines' "expresses."

No. 42 is a four-wheel coupled mixed traffic engine,



ENGINE NO. 868, BUILT IN 1892.

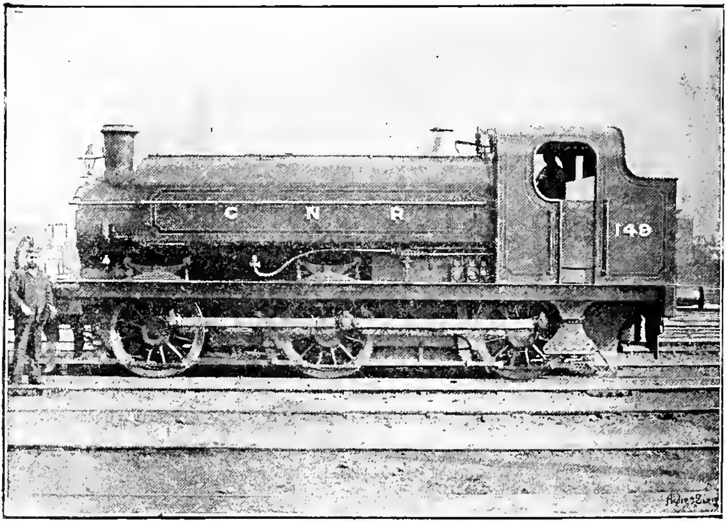
being used for both passenger and goods. The engine is somewhat smaller than No. 868, and differs in having its four coupled wheels in front of the engine instead of at the back. This style is being adopted by other railway companies, with slight modification, which is sound proof of its qualification.

The Company has of late experienced so much difficulty in getting its coal traffic through its crowded suburban district, that in future an engine from the north will leave its load at Hornsey, run on light as far as Harringay, and cross the main line by an overbridge,

ENGINE NO. 42.

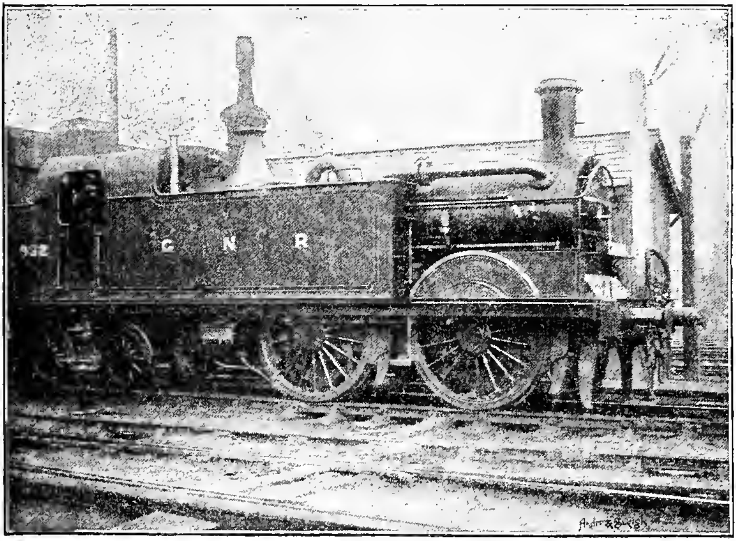
turn, get coal and water, and return with a train of empty wagons waiting ready.

The Directors of the Great Northern Railway deserve every praise for this act of philanthropy, since, at an enormous cost, these works have been carried out more especially to enable engine-drivers and firemen to reach home again somewhere within a reasonable working day. By this arrangement, additional engine power is required to bring the coal to the different London depôts and shunting. For this purpose several new six-wheel coupled engines have been built with tank over the boiler; they weigh in working order forty-seven tons. The Great Northern Railway has an



TANK ENGINE BUILT FOR THE DOCK TRAFFIC.

extensive traffic at Poplar Dock and Royal Mint Street by an agreement with the North London and Great Eastern Railways. At Stratford there is a very low bridge, so that they have had to construct special engines for the traffic with small wheels and low funnel. This engine has the tank over the boiler, six-wheel coupled, seventeen and a half inch cylinders, and twenty-six inch stroke. The weight in working order is forty-three and a half tons. Another specimen of engine very interesting to North London suburban residents is the local passenger engine of the "932" class. These



ENGINE NO. 932, BUILT IN 1892.

engines are constructed to condense their waste steam so that they may run on the Metropolitan Railway to Moorgate Street, and also form a connection with the southern lines *viâ* Snow Hill and Blackfriars Bridge. The cylinders are eighteen inches in diameter, with twenty-six inch stroke, and the engine, which carries its water in the tanks at the side, weighs in working order nearly fifty-four tons.

The South London Goods and Coal traffic having become so heavy, it was deemed desirable to build engines of more strength. No. 924 is a specimen of the locomotives in question, which condense their own steam for the same reason explained in the case of No. 932. The engine of which an illustration is given has cylinders of 18 inches diameter, 26 inch stroke; the total length is 31 feet 9½ inches, and weighs in working order 50½ tons.

A notable feature about the engines last described, is the splendid protection afforded to drivers and firemen by the cab being closed in both back and front.

We now come to the "Race-horse" class of the Great Northern Railway locomotive, viz. the world-famed eight feet driving wheel engine, which has been rarely equalled and never beaten, and the seven feet six inch driving wheel engine with inside cylinders.

No. 776 is known as one of the Jubilee class of engines, being built in 1887, and was exhibited at both the Newcastle and Edinburgh Exhibitions. The driving wheels are as large and perhaps the largest in the country, being eight feet one and a half inches when new. This style of engine was first built by Mr. Stirling in the year 1870, and such is its fame, that almost any intelligent child knows something about it; and is manifested by the small crowd round the engine (which is generally of this class) on the "Scotchman" leaving King's Cross at 8.30 in the evening.

The universal interest shown is such that the statistics by which a locomotive engineer regards a locomotive will doubtless prove interesting.

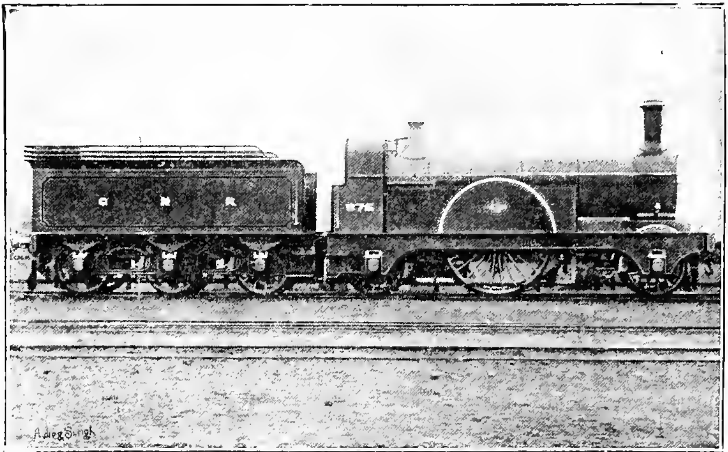
	ft.	in.
Diameter of driving wheels (new)	8	1½
Diameter of cylinders	1	6
Total length over buffers of engine and tender ...	52	4
Working pressure of steam, 160 lbs. per sq. in.		
Number of tubes, 174 of 1¾ in. diameter.		
Heating surface of tubes	936 sq. ft.	
,, ,, firebox	109 ,,	
Total	1,045 ,,	
Grate area	17¾ sq. ft.	

	t.	c.	q.	lbs.
Weight of engine in working order	45	3	0	0
,, tender ,, ,, ...	40	5	3	0
Total tons	85	8	3	0

The tender is capable of carrying 3,300 gallons of water and four tons of coal.

The next class of engine, No. 875, has been painted a neutral tint, so that a good photo may be procured for the Chicago Exhibition. This engine differs from the last by the cylinders being inside the framework and the driving-wheel being seven feet six inches in diameter, and is more economical both in construction and working.

No. 875 is the identical engine that ran the special sporting train from London to Nottingham race-course without a stop. The time allowed was 150 minutes to do 126 miles, and slow up through Peterborough station and Grantham and Colwick junctions, yet it performed the journey about seven minutes under time, and ran equally as well on the return journey.



ENGINE NO. 875, BUILT IN 1892.

The dimensions and particulars of this engine are as follows :—

	ft.	in.		
Diameter of driving wheel (new)	7	$7\frac{1}{2}$		
Diameter of cylinders	1	$6\frac{1}{2}$		
Total length over buffers	49	$1\frac{1}{2}$		
Working pressure of steam, 160 lbs. per sq. inch.				
Number of tubes, 174 tubes $1\frac{3}{4}$ in. diameter.				
Heating surface of tubes	936 sq. ft.			
,, ,, firebox	109 ,,			
Total	1,045 ,,			
Grate area	$17\frac{3}{4}$ sq. ft.			
	t.	c.	q.	lbs.
Weight of engine in working order	40	13	0	0
,, tender ,, ,, ...	40	5	3	0
Total weight of engine and tender	80	18	3	0

The first of this class of engine was built in 1886.

The Royal Saloon, No. 2408, which next claims our attention, is 63 feet 10 inches long and weighs 29 tons 18 cwt., carried on two bogie carriages of six wheels each, fitted throughout by electric light and heated by hot-water pipes, and is fitted with the automatic vacuum and the Westinghouse continuous brakes. There are six compartments and a corridor. The first compartment is the Princess's sleeping apartment, trimmed in sage green, and decorated with white enamel and hand-painted ceiling, with lavatory. The saloon and dining apartment is lined with rosewood and painted ceiling, trimmed with peacock blue. It contains two tables and six easy-chairs. One of the tables is telescopic, and although it appears similar to a very light card-table, it will assume a length enough for six people to dine at. The smoking apartment (which is oak lined) immediately adjoins; it contains three chairs and is hung with amber. Next in order comes the Prince's sleeping apartment, lined with cedar, and fitted with a couch and bed exquisitely upholstered, and has lavatory attached.

Returning to the corridor we now reach the sleeping apartment of the lady-in-waiting, which is very similar in decoration to that of the Princess's.

The next is the sergeant footman's apartment, trimmed in royal blue ; and lastly the attendant's room, in which is the heating stove for the hot-water apparatus, and also the electric light switches and bell disc board.

The Company has recently adopted Pintch's oil gas system for lighting the carriages. There are works for making the gas at London, Doncaster, Leeds, Nottingham, and Boston. The works in London are situated near Highbury, on the Canonbury branch. The machinery is all in duplicate, and these works are reputed to be the best of their kind in the world.

At those stations where there are no works, the gas is supplied by means of travelling tanks, having a capacity of 240 cubic feet, which are attached to passenger trains.

For the convenience of the long-distance Scotch traffic, the Great Northern, North-Eastern, and North British Railways have jointly had built a large number of carriages, dining and sleeping cars, and brakes. Nearly all this stock is built at the Doncaster works on the Great Northern principle and pattern, and is fitted with both the Westinghouse and automatic vacuum continuous brakes.

It was among this joint stock that the first third class corridor lavatory carriages were brought out, and now the Great Northern has built some for their own exclusive use. When the Company first adopted the continuous brake they chose the simple vacuum, but, owing to the inefficacy of the brake (should a slight leakage occur or train break away), it was decided to reverse the principle, and thus easily convert it into an automatic brake. It will perhaps be clearer if it is explained that in the original idea, to apply the brake the air was all drawn out ; now the air must be drawn out and a vacuum maintained to keep the brake from operating, so that should a train break away or in some way become disconnected, the brake applies itself, and the train is brought to a standstill in a few seconds even at the highest rate of speed.

The Company has under its sole control four hotels, viz. at King's Cross, Peterborough, Leeds, and Bradford.

There is a Superannuation Fund for almost all grades of the service, to which the Company subscribes very largely. The fund has been instituted seventeen years, and in 1891 reached £259,627.

The Company paid in the twelve months (to June 1892) £111,218 in rates and taxes, and had a rent-roll of something like £53,176.

The raised capital of the Company was in June 1892, £39,449,562. The gross receipts were for the twelve months £4,434,734, working expenses £2,663,806, equal to sixty per cent. of the earnings, with a train mileage of 18,931,536.

There is a Literary Society at King's Cross station for the use of the Company's servants, and should they be at the utmost extremity of the Company's system they may enjoy the privilege of changing their books carriage free. There is also an Athletic Association for the clerical staff only, with a long list of patrons, all being Directors and officers of the Company. The association embraces cricket, football, swimming, and cycling, and although no records are broken, much healthful recreation is derived. The Company also provides out of its own staff some companies of the Tower Hamlets Engineer Volunteer Corps. The corps has erected at Holloway on the Company's property a drill hall, where the men receive every instruction connected with an engineers corps.

CHAPTER IV.

THE NORTH-EASTERN RAILWAY AND ITS ENGINES.

BY WILSON WORSDELL,
[Chief Locomotive Superintendent.]

THE North-Eastern Railway was formed in 1854 by the union of the York, Newcastle and Berwick, the York and North Midland, the Leeds Northern and the Malton and Driffield lines; it practically monopolizes the traffic of the north-eastern counties of England. Stretching from Doncaster and Sheffield in the south, to Normanton, Leeds, and Bradford in the West Riding of Yorkshire, to Hull, Scarborough, and Whitby in the East Riding, the line runs through the city of York, at which point the Great Northern, Midland, and Lancashire and Yorkshire Companies all work into the North-Eastern Company's station. The main trunk line proceeds from York in a north-westerly direction, and branches run from it to the west, touching the Midland at Hawes, and the London and North-Western at Tebay and Penrith; to the east the main line serves the manufacturing centres of Stockton, Middlesborough, Hartlepool, Darlington, and the great mining districts in the county of Durham, while from Durham a branch line leads to Sunderland. The main line, continuing through the picturesque Team Valley, brings the traveller in about twenty minutes to the city of Newcastle, where the Tyne is spanned by Stephenson's famous high level bridge. From thence the railway passes through the county of Northumberland, skirting the sea-coast nearly all the way, and after passing near Alnwick reaches the border town of Berwick, by the celebrated bridge which crosses the Tweed (designed by the late Mr. T. E. Harrison, C.E., who was for many years chief engineer to the Company). From Alnwick, a recently constructed branch line runs in a northerly direction across Flodden Field to the border town of Coldstream. Branching off westwards from Newcastle, another section of the line passes through the village of Wylam, the birthplace of the Stephensons, and other places of interest, until it reaches Carlisle, the junction for seven different English and Scotch railways.

From Berwick to Edinburgh the railway is the property of the North British Company, but the whole of the "East Coast" express trains are worked to Edinburgh by the North-Eastern Company's engines. This is the route of the well-known "Flying Scotchman." Leaving King's Cross or Waverley at ten o'clock in the morning, travellers may reach either metropolis at half-past six in the evening, a fine performance even in these days, seeing that the distance of 395½ miles is covered in eight and a half hours, inclusive of the stop for dining at York. When the races between the east and west routes were on in the summer of 1888, the

Scotch express cleared the eighty and a half miles from York to Newcastle in eighty-two minutes, and ran from Newcastle to Edinburgh, a distance of 124½ miles, in 128 minutes, reaching Edinburgh at 5.26 p.m., or one hour and four minutes earlier than the present advertised time. It is on this section that the express which leaves King's Cross at 8.30 p.m. runs from Newcastle to Edinburgh in two hours forty-six minutes without a stop, one of the longest runs made by an engine without stopping to take in water.

The oldest section of the North-Eastern Railway is the Stockton and Darlington line, which, in fact, is the oldest bit of railway in the world, having been opened in 1825, though not amalgamated with the North-Eastern until 1863. The entire system comprises about forty-two railways originally independent, but amalgamated at various times, in some cases before incorporation with the main system : the last amalgamation was with the Blyth and Tyne Railway, which was acquired in 1874.

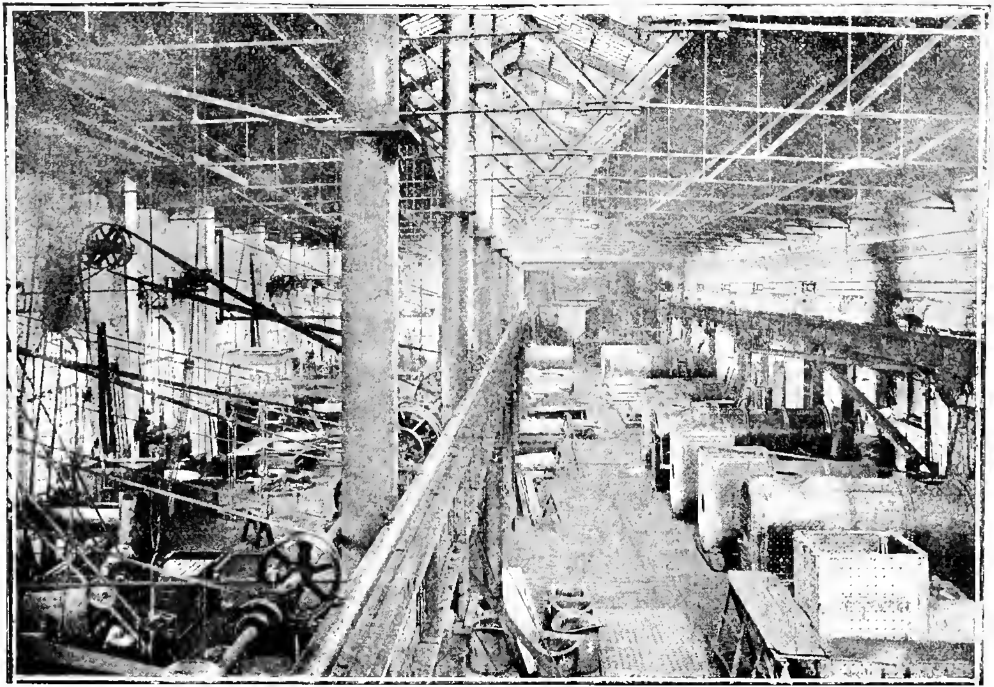
The length of line worked by the Company is 1,578 miles, and the train mileage run in the year 1891 reached a total of nearly twenty-seven millions; the engine mileage exceeded forty-one millions, which is not far short of half the earth's distance from the sun. The amount of capital sanctioned up to December 31st, 1891, was £61,149,365 ; the revenue last year amounted to over £7,000,000, and the expenditure to over £4,000,000, leaving a balance of fully £3,000,000 for the payment of interest and dividends.

The rolling stock comprises 1,742 locomotives, 3,281 carriages, and 83,500 wagons; the wagons alone, if made up into one train, would reach 271 miles, the distance from London to Newcastle. For road traffic there are 1,763 carts and rulleys, and 1,376 horses. The number of servants in the Locomotive Department is 12,840, including those employed in repairing carriages and wagons; 4,931 are engaged in working the locomotives, and the total staff of the Company numbers 38,000. The coal consumed by engines in 1891 amounted to 650,000 tons, and the weight of water used for all purposes was about 8,000,000 tons. There were 22,183 special trains run in 1891, of which 9,377 were passenger and 12,806 goods. The weight of tickets issued to the public was thirty-nine tons, and the number of passengers carried reached a total of forty-seven millions. The goods traffic amounted to 9,283,600 tons, and the minerals to 32,493,238 tons. There are 533 stations on the line and 1,001 signal cabins. The signal levers in use number 13,000, and 9,270 lamps are lighted nightly.

The head-quarters of the Locomotive Department are at Gateshead, but the locomotive works at Darlington are almost as important, and there are also large engine works at York. The Gateshead works were largely rebuilt, extended, and thoroughly reorganized in 1883 and 1884. Though not so large as the Crewe or Swindon works, they are second to none in the excellence of the tools and machinery used, and in the quality of the work produced. Since Mr. T. W. Worsdell's accession in 1885, the machine power has been further increased, particularly in the use of milling machines for finishing connecting and coupling rods, the rods and levers of valve-gear, and other heavy work. Mr. Worsdell introduced the use of steel plates for boilers in place of Yorkshire iron, and laid down special gas furnaces for annealing the plates, the result of the change being a great saving in the cost of material for boiler construction.

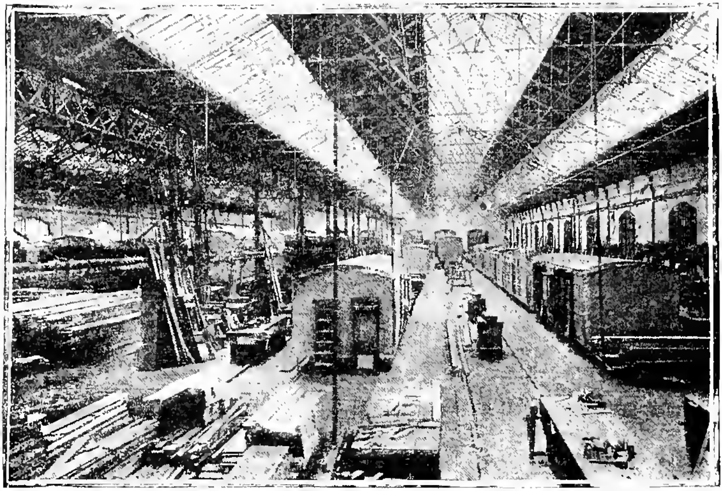
In the Boiler Shop a special feature is the introduction of hydraulic presses for flanging purposes, the old system of flanging plates by hand being thereby superseded and a considerable saving effected in cost. Steel castings have also been brought into use for wheel centres of all sizes, fire-box, roof bars, reversing shafts, and other purposes, for which forged iron was previously employed. Among the improvements made by Mr. Worsdell during the five years he held the office of Locomotive Superintendent for this Company, may be mentioned the testing house at Gateshead, where the strength of various specimens of iron, steel, and copper is ascertained by means of a powerful hydraulic machine. For example, a piece cut off each plate intended to be used for boilers is tested, labelled, and stored up for future reference. During his period of office, large and commodious dining-rooms, as well as rooms for lectures, concerts, reading, and evening classes were built at Gateshead and York for the use of the workmen. The Gateshead Institution is capable of seating about 1100 men. Meals are cooked in gas ovens without charge, and every man's breakfast or dinner is numbered and put in his place just before the electric bells ring, announcing in the various shops the approach of the meal hours.

The Company has extensive workshops at York, for building and repairing carriages and wagons, also wagon



THE BOILER SHOP.

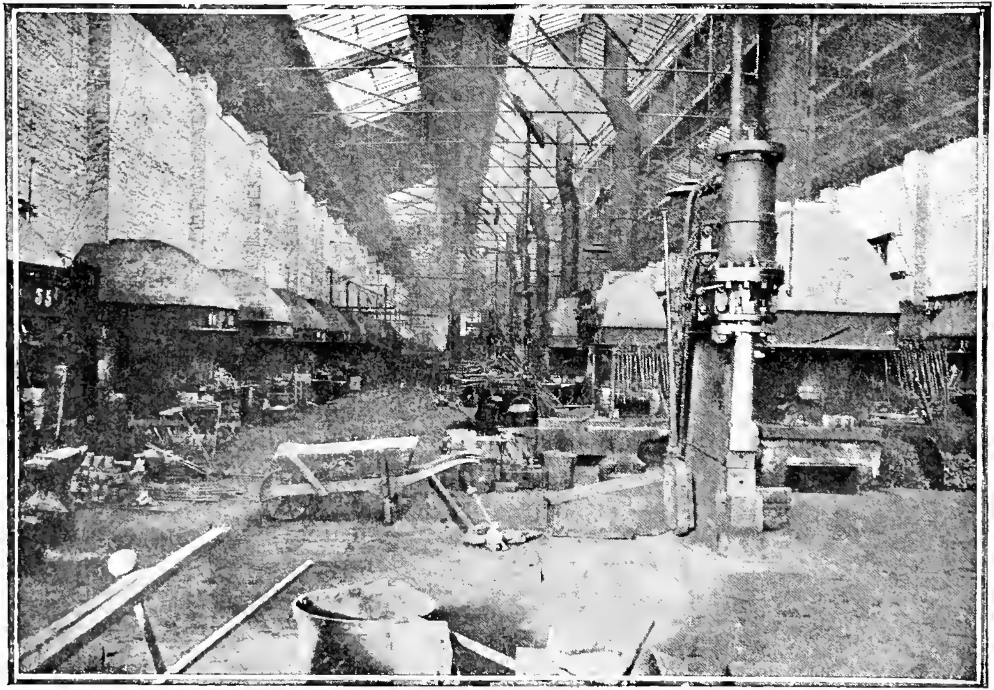
works at Shildon, and repairing shops at Gateshead, West Hartlepool, Tyne Dock, and Percy Main. Nearly 3000 men are employed upon this class of work, and in order to give an idea of the magnitude of the task to be performed in maintaining the rolling stock of a large



CARRIAGE-BUILDING SHOP.

railway company, it may be mentioned that, in the past year, 200 new carriages were constructed, 100 rebuilt, and 8,700 passed through the workshops for repairs, while 2,180 wagons were built as additional stock, 3,750 were renewed, and 159,000 repaired. For the examination and greasing of carriages and wagons when working in trains, a staff of about 470 inspectors and greasers is constantly employed.

The North-Eastern Railway Directors have adopted

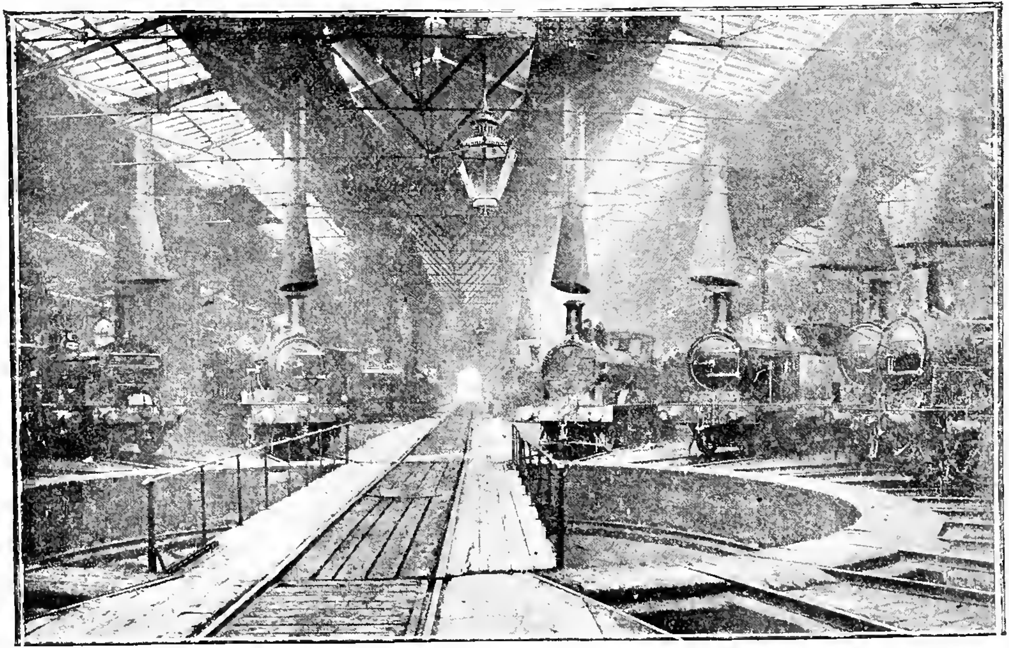


THE FORGE SHOP.

Pintsch's patent oil gas system for lighting carriages. Gas works have been erected at Newcastle, York, and Hull, the three places being capable of producing 24,000,000 cubic feet of gas per annum, the illuminating power of which is about four times that of ordinary coal gas. Fifteen hundred vehicles have already been fitted with the gas apparatus.

The North-Eastern for the last ten years have used the Westinghouse air-brake, which has given perfect satisfaction, fulfilling, as it does, every requirement of the Board of Trade. The continuous brake and the absolute block system of signalling are two of the greatest improvements ever made in railway appliances, and to these is no doubt largely due the comparative rarity of serious railway accidents during the last fifteen or twenty years. Previous to their introduction, the amount paid by the North-Eastern Railway Company in compensation for personal injury averaged about a halfpenny per passenger per annum. During the five years ending December 1891, the average was one-twelfth of a penny, and in the year 1891 only one-thirtieth of a penny per passenger.

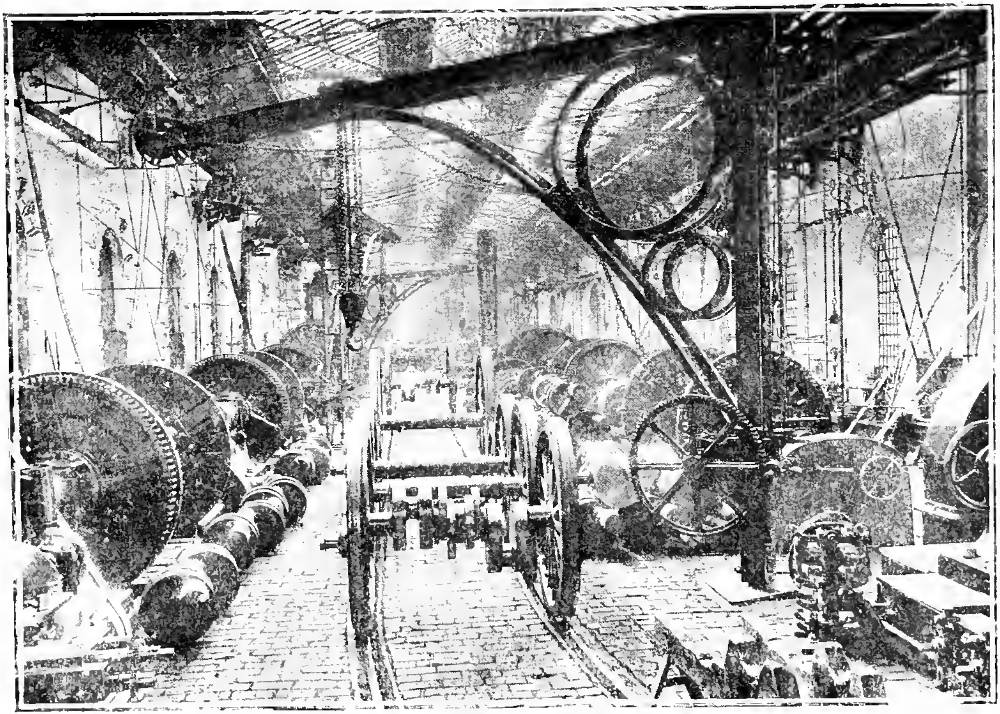
In addition to the working of the locomotives and the maintenance of rolling stock generally, the Locomotive Department is charged with looking after some 400 stationary boilers, fourteen steam-tugs, 320 steam and hydraulic cranes, 104 pumping engines, 115 turntables, sixteen steam fire-engines (nine of these being kept on tug-boats in the docks and ready at any moment in case of an outbreak of fire amongst the shipping) and fourteen manual fire-engines.



ENGINE STABLE.

It may easily be imagined that to maintain all these appliances, and to keep them in good working order, a great deal of supervision and labour is entailed. For the stabling of the locomotives, there are sixty-seven running sheds situated at convenient points on the line. An illustration is given of the shed connected with the Gateshead Works, which, together with the other shed at Gateshead, has accommodation for 250 engines.

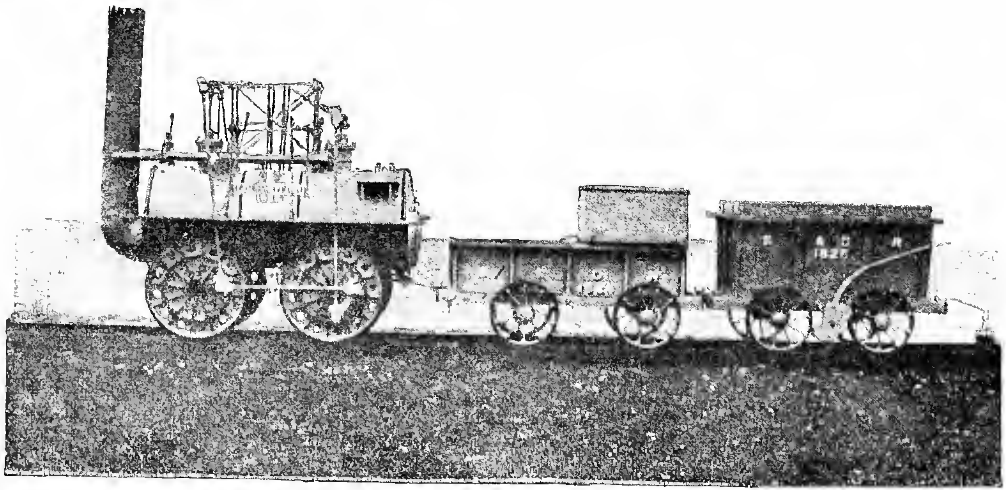
Visitors to the Newcastle Exhibition in 1887, or to the Edinburgh Exhibition in 1890, will remember the contrast between the earliest and latest type of locomotive possessed by the North-Eastern Railway Company. The former, George Stephenson's No. 1 engine, "Locomotion," was built for the Stockton and Darlington Railway in 1825, and ran its first public trip on the day of the opening of that line, September 27, 1825, and its last on the occasion of the opening of the line from Middlesborough to Redcar on June 4, 1846, a distance of $7\frac{3}{4}$ miles, which was performed in twenty-five minutes. This engine has travelled many thousands of miles to and from exhibitions, having been exhibited at Chicago in 1883, at Newcastle in 1887, at Paris in 1889, and at Edinburgh in 1890. On account of the great historical value of this engine, it has now been permanently stationed on a pedestal at Darlington, and therefore will not be exhibited elsewhere again. Another of these early locomotives bearing the name "Billy," and being also numbered "1," is mounted at the Newcastle end of the High Level Bridge, and is an interesting object to persons visiting Newcastle. This engine was working at the Killingworth Colliery, and



WHEEL AND CRANK AXLE SHOP.

only ceased from its labours in 1884. It was presented by the colliery owners to the Corporation of Newcastle, and the North-Eastern Railway Company at their request found for it a suitable resting-place. The celebrated "Rocket" engine was built a few years later than "Locomotion," and was the type used on the Canterbury and Whitstable line, opened May 3, 1830, when the locomotive "Invicta" ran the first train, and was driven by the late Mr. Edward Fletcher, who, for about fifty years, held important positions on the North-Eastern system of railways, having retired from the office of Locomotive Superintendent in 1882.

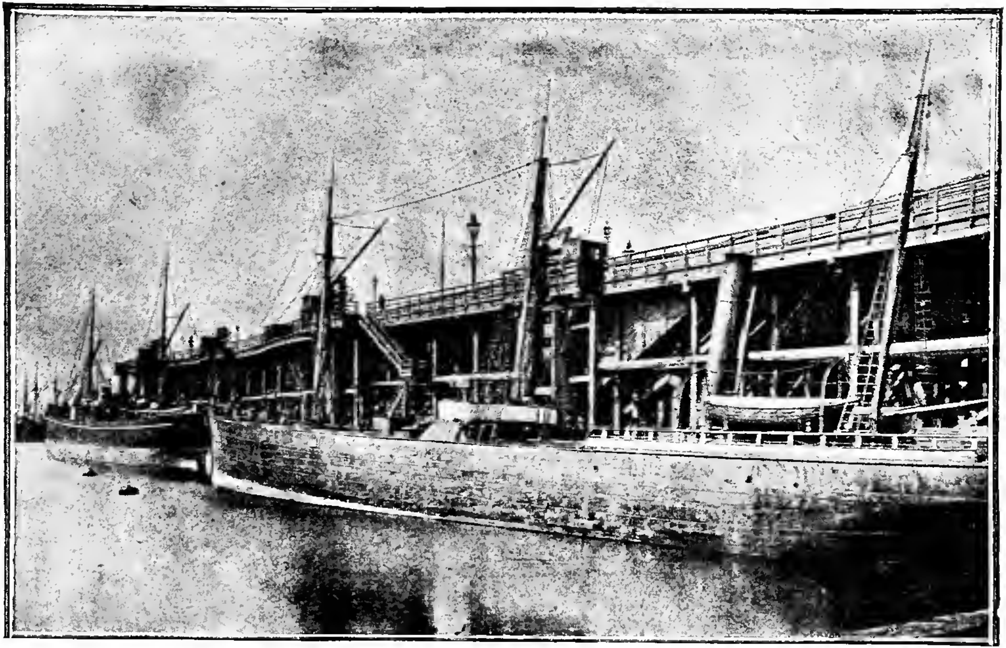
The other engine exhibited at Newcastle was one of Mr. Worsdell's compounds, the first built for the North-Eastern railway, No. 1324. It has cylinders eighteen and twenty-six inches diameter, and twenty-four inches stroke, the driving wheels being six feet six inches diameter coupled to trailing. The engine exhibited at Edinburgh was specially designed for working heavy express passenger trains between Newcastle and the Scottish capital, and is the most recent type of passenger engine on the North-Eastern Railway; its cylinders are twenty and twenty-eight inches in diameter, and twenty-four inches stroke, the driving wheels being single, seven feet six inches diameter. The horse-power indicated when running at eighty-six miles an hour on a level road with eighteen carriages on, was 1,068, the total weight of train being 310 tons. The average coal consumption of these engines, of which ten have now been built at the Gateshead Works, is about 28½ lbs. per mile, which is very low for heavy traffic at a high rate



STEPHENSON'S "LOCOMOTION," BUILT 1825. NOW STANDING ON A PEDESTAL IN DARLINGTON STATION.

of speed, in fact about two pounds lower than the average of any other class of engine on the line. Altogether forty-seven compound express passenger engines have been built at Gateshead, and, including 212 goods engines, the Company have built 259 compounds since this system was adopted scarcely six years ago. The "Worsdell and Von Borries" compound locomotive, as is well known, differs from the "Webb" compound in its greater simplicity of construction; indeed there is nothing to distinguish it from an ordinary engine, except that one cylinder has a larger diameter than the other, and a special valve is fixed inside the smoke-box to assist in starting the engine, when, owing to the position of the cranks, it is necessary to admit steam direct to the low-pressure cylinder. The valve closes automatically before the wheels have completed their first revolution, and, after that, it is only through the high-pressure cylinder that steam can reach the other.

The North-Eastern Railway Company own extensive docks at Tyne Dock, West Hartlepool, and Middlesborough, besides a small dock of six acres at Sunderland. At Tyne Dock the water space extends over fifty-five acres, including Timber Ponds, and during the past year 4,880 steamers and 1,572 sailing vessels were received into the Docks. This dock is famous as being the place where the largest quantity of coal is shipped in any single dock in the world. The illustrations of this place show in one instance the appearance of the dock during the Durham miners' strike, no less than forty-two vessels being accommodated whilst waiting for orders, and in another a view of one of the jetties with two

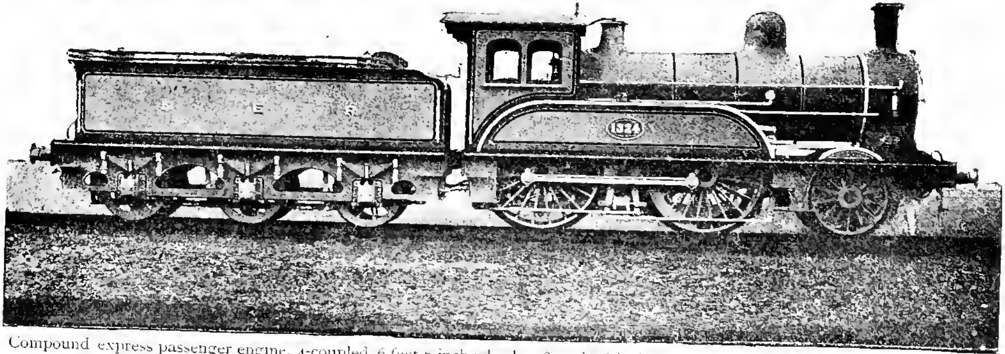


COALING JETTY, TYNE DOCK.

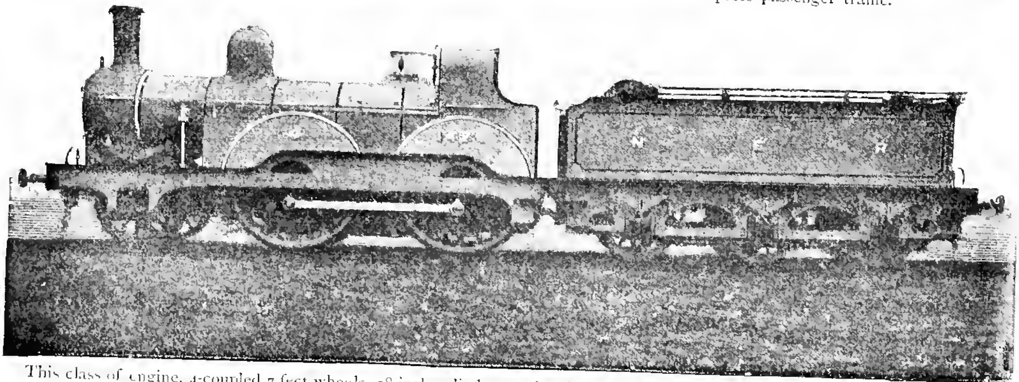
steamers lying alongside waiting to be coaled. There are four of these jetties at which eighteen vessels may be coaled simultaneously. The coal wagons run by gravitation on to the jetty; here a man releases the bottom, which is made with two doors to fall when a

NORTH-EASTERN COLLIERS ANCHORED DURING THE DURHAM COAL STRIKE, TYNE DOCK.

pin is withdrawn. The coal passes through an opening in the jetty and down a large shoot into the hold of the vessel, the empty wagons returning by gravitation down another set of rails, whence they are taken back to the colliery to be refilled. By this means the Company have shipped 27,000 tons of coal in twenty-four hours,



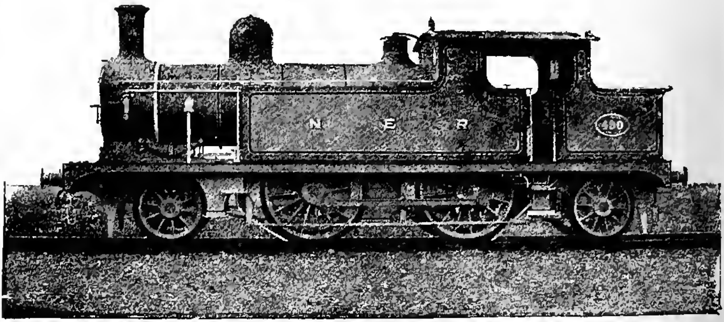
Compound express passenger engine, 4-coupled 6 feet 0 inch wheels, 18 and 26 inch cylinders, and 24 inch stroke, boiler pressure 175 lbs., was designed in 1886 by Mr. T. W. Worsdell for main line express passenger traffic.



This class of engine, 4-coupled 7 feet wheels, 18 inch cylinders, and 24 inch stroke, was built in 1885, at the time the Company was without the services of a Locomotive Superintendent. The General Manager, Mr. Henry Tennant, undertook the direct supervision over the department at that period, and hence these engines are named the "Tennant Express."

130,000 tons in a week, and during the past year 5,924,000 tons.

At West Hartlepool the docks cover seventy-three acres, and are constantly crowded with vessels from all parts of the world. There is a very large trade in eggs at this port, some 9,000 tons being imported in the course of a year; also a very large timber trade, for



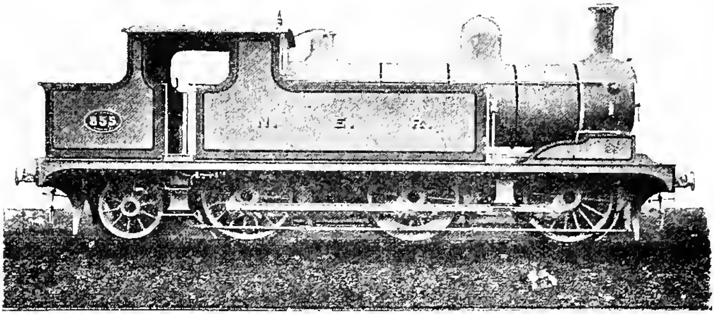
Passenger side tank engine, designed by Mr. T. W. Worsdell, 4-coupled 5 feet 6 inch wheels, 18-inch cylinders, and 24 inch stroke, built in 1886 for local passenger trains; it has 4 intermediate wheels coupled, and a pair of wheels with radial axle-box at each end.

which ponds covering an area of fifty-seven acres have been specially provided. At Middlesborough the docks occupy a water space of sixteen acres, and here vessels are loaded with coal, steel rails, steel sleepers, and cast-iron "pot" sleepers for the Indian and other railways abroad. Large hydraulic cranes have been specially provided at Middlesborough for loading the iron and steel products. At all the North-Eastern docks the most modern hydraulic machinery is fitted for the quick

YORK STATION (NORTH-EASTERN RAILWAY).

loading of vessels and storing of goods in the warehouses.

It may be appropriate here to make a reference to the marvellous change that railways and steam power have brought about in the means of travelling. Only 200 years ago, the roads of England were so bad that oftentimes a coach stuck fast in the mire and a farmer's



Compound goods side tank, with 8 wheels, 6 of which are coupled, the other pair being fitted with radial axle-box of the same design as those on the side tank passenger engines. It has 5 feet wheels, 18 and 26 inch cylinders, and 24 inch stroke. A powerful engine, designed for local goods and mineral traffic.

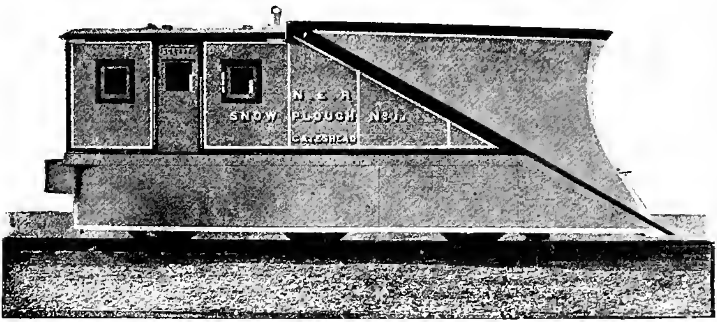
team was needed to drag it out. The rich travelled in their own coaches, but six horses at least were required to overcome the badness of the roads. Towards the close of the reign of Charles II., coaches began to run thrice a week from London to the chief provincial towns, but no conveyance went further north than York, a journey that occupied six days in winter, and which is now performed several times a day all the year round in four hours! When it was proposed to run a "flying coach" between London and Oxford, leaving Oxford at

6 a.m. and arriving in London at 7 o'clock in the evening of the same day, the undertaking was considered to be both difficult and dangerous. Fifty miles *a day* was the usual speed in summer and thirty in winter, distances which correspond to our present speeds *per hour* for express and stopping trains respectively. The fares for such travelling were twopence halfpenny per mile, or about the same as first-class railway fares now. On April 12th, 1706, a "York Four Days Stage Coach" was started. It left the "Black Swan," Holborn, every

STANDARD CRANK AXLE, NORTH-EASTERN RAILWAY.

Monday, Wednesday, and Friday, and "(if God permits) performs the whole journey in Four Days. And sets forth at Five in the Morning." The York terminus was also the "Black Swan," in Coney Street, from which the up coaches started on the same days and at the same hour. Another service, two days a week only, was run between York and Newcastle.

Snow-storms sometimes cause much destruction to property and serious loss of traffic on the line; the storms in March 1886 and March 1888 were especially severe, the main line from Newcastle to Edinburgh being blocked so that no trains were able to pass over it for several days; trains were completely buried in the snow, and the passengers had to remain imprisoned until relieved by the snow-ploughs or by gangs of men sent to dig them out. These two storms, it is estimated, cost the Company about £100,000, including loss of traffic. Since the last great storm, the Company have built some very strong and effective ploughs which, it is



STANDARD SNOW-PLOUGH.

expected, will greatly facilitate the removal of snow in future.

It will be readily understood from the above description, that the superintendence of the locomotive and carriage department of such a railway as the North-Eastern is a very considerable undertaking. Mr. Wilson Worsdell, the chief of the locomotive, carriage, and wagon departments, resides at Gateshead. His principal assistant in the locomotive department is Mr. George Graham of Darlington, who is assisted by Mr.

Vincent Raven in the Northern Division and by Mr. John Murray in the Southern Division. The principal Managers of the works are Mr. Robert Stirling at Gateshead, Mr. W. Younghusband at Darlington, and Mr. W. Carr at York. Mr. Worsdell's chief assistant in the carriage and wagon department is Mr. David Bain, who is Manager of the York carriage and wagon works.

CHAPTER V.

THE GREAT EASTERN RAILWAY WORKS AT STRATFORD.

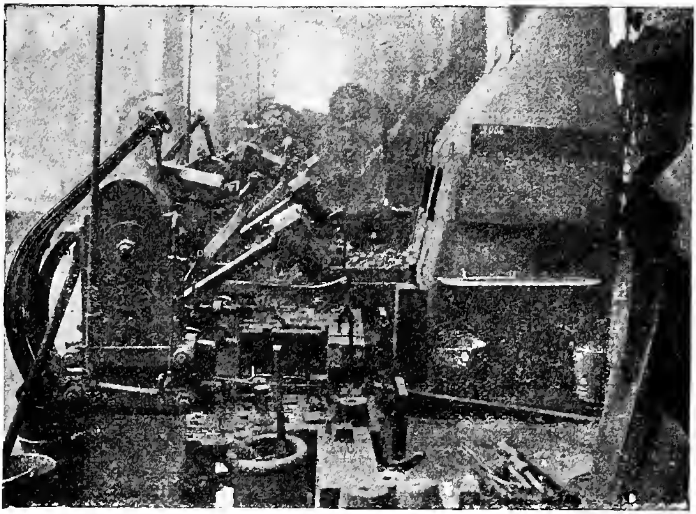
BY ALEX. P. PARKER,
[Secretary to the Locomotive Superintendent].

THE Eastern Counties Railway, the forerunner of the present Great Eastern, was incorporated on July 4, 1836, and as scheduled was the longest line which had yet obtained the sanction of Parliament. It was constructed to a five-feet gauge, and commenced its career as a public carrier on June 20, 1839, when it opened from Mile End to Romford, at which latter station the first repairing shops were built. It is a matter of history that the anticipations of the first Chairman, who held out to an exceptionally sanguine proprietary "a prospect of one of the proudest triumphs of the march of science," were not fulfilled, and we will lower the veil over its misfortunes and misdeeds. Suffice it to say, that in 1862 it was considered expedient to consolidate the wisdom of some eighty Acts of Parliament by an amalgamation scheme under a new nomenclature. But the "Great Eastern" phœnix which arose from the ashes of the Eastern Counties was not at first more successful than its progenitor, and in 1867 the locomotives were seized at the instance of creditors, and loaned to the Company. In order to get out of this difficulty, and to put the line and rolling-stock into better condition, it was deemed necessary to apply for power to raise £1,500,000 extra capital; but the application, although made under the auspices of the present Marquis of Salisbury, who was Chairman at the time, was refused; so, as Mr. Acworth amusingly puts it, "the Company amended their Bill, asked for £3,000,000, and got it." Gradually an improvement became manifest, and under the guidance of Mr. C. H. Parkes, who assumed control in 1872, has continued, until the Great Eastern Railway now holds the premier position for punctuality of all lines running into London.

The Stratford Works were built by the Eastern Counties in 1847, during "King" Hudson's reign, at a cost of £100,000—a mere trifle to a concern claimed to rest "on the broad and stable basis of national utility," and therefore dismissed in the Directors' report with a few remarks about "the shops at Stratford being in progress." Comprehensive as they were for the requirements of the day, they have been in progress ever since; but the Great Eastern being still the reverse of a rich Company, and the original works being hemmed in on one arc of a circle by Stratford New Town, formerly known as "Hudson's Town," and on the other by a network of main lines and sidings, considerable ingenuity has had to be exercised in covering in here, or building an extra storey there, and so making the most of the available space. Human ingenuity, however, has its limit, and we shall see that on the further side of the main line, away among the marshes, more modern buildings have had to be erected to provide for the largely increased rolling-stock.

Let us begin by a walk through the Steam Hammer Shop, keeping in mind that we are in the "Hudson" Works. There are here five steam hammers thumping away night and day, fed by four coal and three gas furnaces, the glare from which when a door is momentarily raised is almost blinding to a novice. The head forgeman is a certificated member of the St. John Ambulance Association, which has a strong corps in Stratford Works, and first conducts us to one of the well-appointed Ambulance cupboards with which every shop is provided. But this, although of considerable importance when we bear in mind the risks of personal injury with which mechanics have to contend, is hardly what we want on this occasion. "Well, come and look at these butterflies." Then we remember he has a penchant for entomology, but are relieved on finding that his "butterfly" is a forging, and very interesting it is to see how the grain of the iron is worked at different angles, to ensure that in the spring clip which is the finished form of the "butterfly" the greatest possible strength shall be in the directions where it is most needed. On the way we notice men packing "piles" of wrought-iron scrap, such as old drawbars, couplings, and the waste from stampings, on boards about fourteen inches square. Each pile is brought to a welding heat in the furnace, and is then hammered into a "bloom," which after re-heating is in some instances stamped under the hammer between suitably shaped dies, and in others simply pounded into shape by the heavy blows which, metaphorically speaking, rain upon it, the forge-men's deft manipulation of the glowing mass as they turn and twist it between each blow, and their weird appearance as the fiery flashes illumine their dusky faces, creating an impression on the mind which is not easily forgotten. We make arrangements for a photograph showing the processes from pile to finish of a quadrant link and spring clip, and then walk into the adjoining Smithy, where we see some 280 men busily engaged on the smaller forgings appertaining to a locomotive, the clang of the hand-wielded hammers forming a striking contrast to the ponderous thud of their steam-fed neighbours. On one side of this shop we notice a row of curious-looking machines for making bolts, ferrules, and other small details. These are known as "Olivers," and have a forty-pound hammer poised in the air ready to descend at any moment by foot pressure on a treadle fixed in a trough on the floor; thus, instead of a man's whole services being required for striking as at an ordinary anvil, one leg suffices, and the hands are free to ply the tongs, and give the finishing touches to the work with an ordinary hammer.

Passing again through the Steam Hammer Shop we enter the Boiler Shop, and are shown a vertical rolling-machine, not unlike a huge domestic mangle standing on its side, between the rolls of which great plates of steel, which have previously had the rough edges planed and the rivet-holes drilled or punched, are passed and bent barrel-shaped. The barrel is then bolted together with its rings and straps, and conveyed by overhead travelling cranes, of which there are six, with a lifting capacity of ten tons each, to an "iron man" actuated by hydraulic force, whose jaws measure six feet long, and

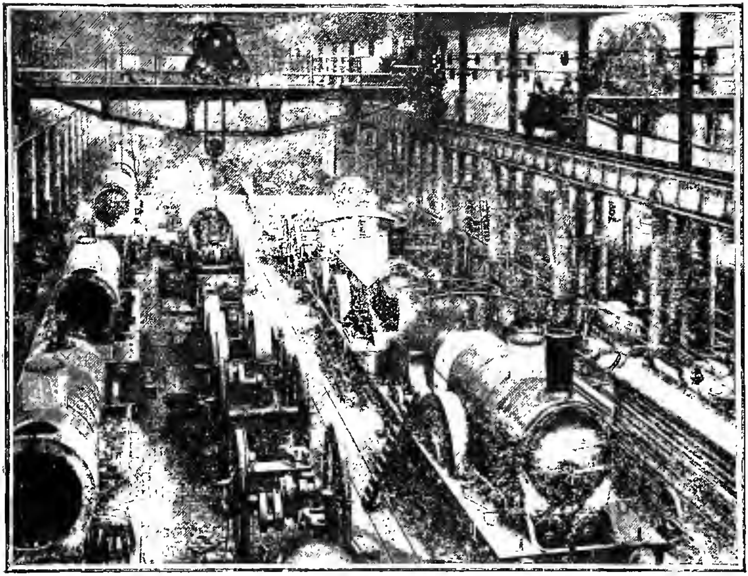


GROUP OF OLIVERS.

who with a pressure of forty-one tons "closes up" the red-hot rivets as they are placed in position by the workmen. The riveting of less accessible parts is performed by portable machines, also hydraulic, in appearance like the gripping claws of a crab, and their silent though determined clench when brought into position makes one wish that hand-riveting with its incessant clattering could be abolished altogether. Punching, shearing, and planing machines attract attention by the apparent ease with which they treat cold steel, but so great is the force employed that the mere act of punching out a piece $1\frac{1}{2}$ inches in diameter, and $1\frac{1}{8}$ inches thick, raises its temperature about 70° Fahrenheit in less than a second. We ask how many holes are punched in a year, and are told that at four of the machines close by the records of nine men show an aggregate of over seven millions, the weight of the punching alone amounting to nearly 250 tons. Outside the Boiler Shop are gas furnaces for plate heating, and two hydraulic flanging presses, the power of which comes from a drum-shaped accumulator containing about forty-three tons of ballast, the accumulator being poised on a cushion of water forced through a central column by a pair of vertical pumps. This apparatus certainly has the charm of simplicity: a red-hot plate is brought from the furnace and secured between two iron slabs smaller than the plate itself; a valve is then opened in a pipe connecting the column with the press, and the weight of the accumulator forces the water against a twenty-inch ram, which in its rise presses a suitably shaped die against the exposed parts of the plate and turns up the edges all round. In less time than it takes to describe it, we see a flange turned up to a height of three inches, and so silently that one could almost hear a pin fall during the operation. The number of rivets in a locomotive side tank has, by the substitution of flanged plates for angle irons, been reduced from 700 to 350, thus not only effecting an important economy but ensuring additional strength.

Looking in at the Iron and Brass Foundries and the Coppersmiths' Shop, we pass to the Machine Shop, where the twelve thousand feet of leather belting whirling round innumerable pulleys are apt to create a sense of bewilderment, but where in reality everything is of a most orderly description. In the tool store we at once notice a number of gleaming circular tools, varying from half an inch to twelve inches diameter, the latter built up in forty-two segments. These are milling cutters and for an idea of their working one may imagine a coin revolving either vertically or horizontally on its own axis, each tooth of the milled edge being sharpened and set to a particular cutting angle. It thus bites its way into the article operated upon, and we are shown as an example a beautifully finished fluting, three-quarters of an inch deep by two and three-quarter inches wide and six feet six inches long, cut in a cold iron coupling rod at one operation. Another ingenious application of the milling cutter is a tool which at one operation cuts two grooves and machines three sides in a brass index plate. These cutters are also used in the manufacture of "twist" drills, so named through having two spiral grooves in their length something like that in an ordinary auger. The drill "blank" is given a longitudinal and circular motion in a machine, corresponding to the spiral in a metal pattern, a milling tool fixed in the headstock cutting the spiral as the blank travels under it. Other features are sharpening machines with emery wheels revolving at great speed, and sending out showers of tiny sparks as they grind away at cutting tools of various kinds ; slotting, shaping, screwing, and tapping machines ;

bolt and nut lathes; and a little smithy which this shop has entirely to itself. It is in the Machine Shop that embryo engineers gain their first experience, after which they enter the Fitting and Erecting Shop. This building, which measures 350 feet by 150, has six rows

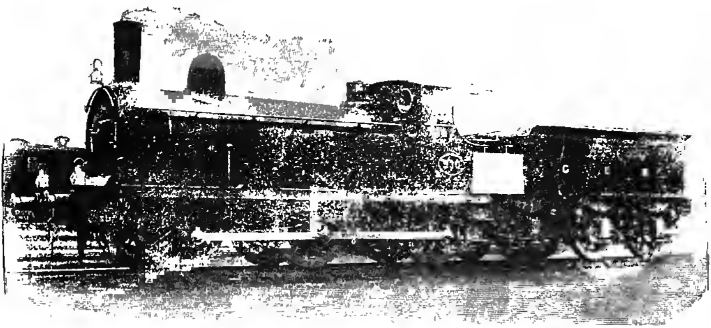


ERECTING SHOP.

of "pits" running lengthwise through the two centre bays for engine construction and repairs, the two side bays being occupied with fitters' benches and heavy machinery. So complete is the organization, so efficient the machinery, and so skilful and willing are the workmen, that in

December last a six-wheel coupled goods engine, weighing with its tender over sixty-seven tons, was erected, painted lead colour, and in steam in the almost incredible space of ten working hours, and after running the usual trial trip was immediately put to work on the London and Peterborough coal service, at which it has since been continuously engaged. With the exception that a greater number of hands were employed, and that special care was taken to lay down the details in order of sequence, the method of construction was the same as that of all engines built at Stratford, and we are given a short description of how an engine is erected. The engine frame plates, originally of rectangular form, come here from the boiler shop punched roughly to the required shape, and are now, so to say, "pared" accurately to dimensions, ten at a time, on a triple-headed shaping machine, after which the necessary holes are drilled, and then the "horn blocks" or axle guards and the spring brackets attached by the fitters; the cylinders, which come on rough castings from the iron foundry close by, are bored, planed, and the attachment parts drilled, and are then tested by steam pressure; the boiler is brought in, and at one end of the shop, given over especially to such work, has its mountings—water-gauges, safety-valves, regulator, &c.—fitted, and is then tested, first by water and then by steam; the many items of the working gear, technically known as the "motion," come from the machine shop, and are carefully fitted up at the benches to ensure accurate working; and the wheels, which have been forced on the axles with a pressure of eighty tons, are brought in and conveniently placed.

We will now watch the progress of erection, noticing first that for the lifting of the heavy parts there are four overhead cranes, each of thirty tons capacity, which traverse the length and breadth of the shop, and are driven by an endless or "flying" cotton rope running at a speed of about half a mile a minute, the cranes being actuated by the bite of the rope on the grooved surface of the pulleys. The engine frames are brought into



ENGINE BUILT AND IN STEAM IN TEN WORKING HOURS.

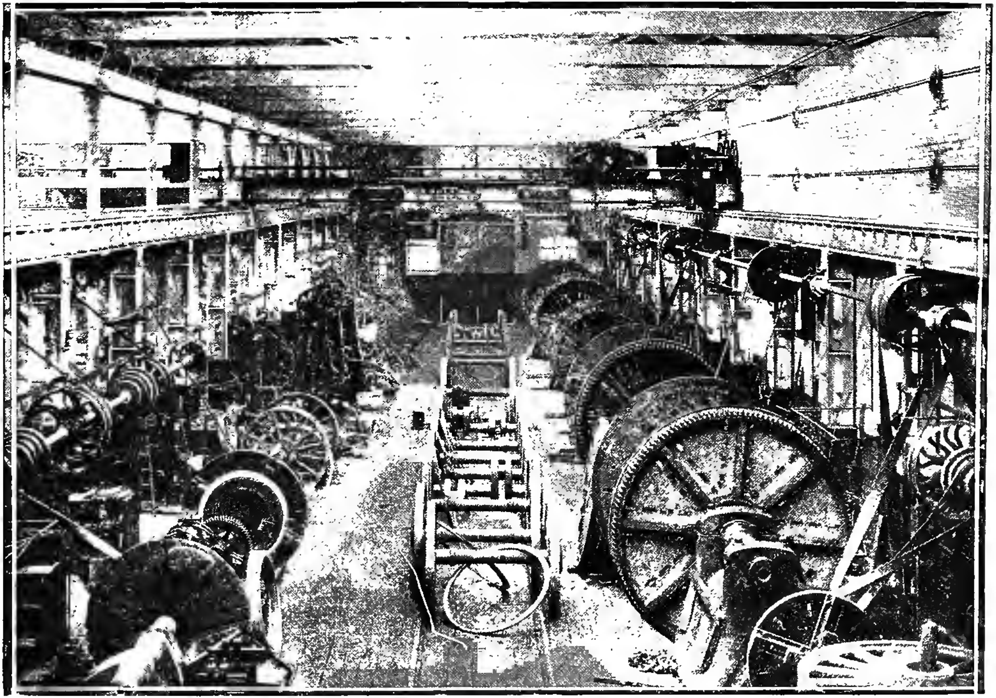
position one at each side of the pit, and are stayed together by temporary bolts; the frame stays and cylinders are then put in and bolted together, the rivet-holes, which have been drilled below the standard size, being reamed out with standard rose-bits actuated by an ingenious arrangement known as a Stow shaft, consisting of wires twisted spirally in a leather casing, thus forming a flexible line, which transmits rotary motion from the main shafting as easily as an india-rubber tube will convey gas or water. The work so far as it has gone is then "squared"; the motion put up; the boiler, which has meanwhile been clothed with wood strips to prevent loss of heat by radiation, is lifted into position on the frames; the cab, smoke-box, and chimney added; the wheels, which have had the axle-boxes fitted to them, put under; the eccentric and connecting rods coupled up; and then comes the setting of the valves which regulate the admission and exhaust of steam through the cylinder ports. Assuming the 9,438 parts contained in a Great Eastern standard goods engine to be now in position, she—for an engine like a ship is generally spoken of in the feminine gender—goes to the weigh-bridge, where the weight on each wheel is adjusted. Then with the tender, which has had its 7,504 parts put together in a shop on the other side of the line, she receives a coat of lead paint, and is despatched on her trial trip, the leading hand of the pit upon which she was built accompanying her, to take note of any little defects that might show themselves. Should all be satisfactory, as is almost invariably the case, she now returns to the shop for painting, preparatory to turning out in the world for a living.

But not only is the engine stock kept in repair at Stratford, and a new engine turned out every thirty-two working hours, there are also the carriages and wagons to be maintained, and new carriages built at the rate of eight working hours, and wagons at the rate of every three and three-quarter hours. Let us walk through the Spring Shop to the Carriage Department, making our first call at the stores. Here, on a duly authorized requisition, can be obtained almost anything employed in railway carriage building, from tinned tacks or ten-penny nails to those beautiful photographs which are now substituted for the old-fashioned, and we regret to say almost unheeded, admonitory notices which were the delight of all travellers with an eye for the artistic. Proceeding on our tour, we come to the Saw Mill, where the usual sweet smell of freshly-sawn timber is quite overcome by the peculiar and unpleasant odour of teak wood, the material of which the panelling of a Great Eastern carriage is constructed. Wood-working machines of all kinds are humming and buzzing, and some shrieking with a faint imitation of a syren, but they are only visible by close inspection, the shafting being below the floor, and the machines almost hidden by the stacks of timber dotted about. We see a match-boarding machine plane two sides of a board at the rate of thirty-five feet per minute, and at the same time form a tongue and a groove; a wood scraper, the fixed cutter of which takes a continuous shaving two feet wide off a panel board; and a machine in which a square-section stick passed through revolving cutters emerges as a round-section curtain rod; and then we go to the timber grounds, where we see hundreds of oak logs from the Galician forests, and from Michigan or Ohio, waiting their turn for conversion into plank. Further on, in sheds from which the sun's rays are excluded, but through which the air is allowed free circulation, are teak and mahogany panels, planks, and scantlings, oak, ash, elm, hornbeam, and other woods, methodically stacked for drying by process of nature.

Returning we pass through a carriage hospital, containing passenger train vehicles in all stages of repair, and come upon a steam traverser. This is situated in an opening between the Repairs Shop and the Body Shop where new stock is built, and is a necessary convenience for enabling carriages to be moved quickly from one set of rails to another on completion or in an emergency. Entering the Body Shop, we are reminded that a peculiarity of wood workers is that each man has his own tools and chest, bought with his own money or made in his own time. These clean-looking men in their white aprons form a strong contrast to the men we have left working among the oil and rust on the locomotive side. No description of carriage work comes amiss to them, a horse-box or a train of dining-cars, a carriage truck or a royal saloon. Walking on, our voices are involuntarily hushed as we draw near a vehicle, which at a few hours' notice was draped with purple velvet and converted into a mortuary car for conveying the remains of the late Duke of Clarence to Windsor, and now stands, in the sad irony of fate, next an elegant saloon, the completion of which had been originally timed for that royal wedding which was destined never to be.

Our course now takes us through a spacious machine shop, in which a machine for testing india-rubber buffing and draw-springs calls attention to the unceasing care bestowed on every item in this vast establishment, in order that neither the lives nor the comfort of the travelling public shall be jeopardized. Then we proceed to an upper story, where trimmers are at work with knife, scissors, needle, and hammer, cutting, stitching, and tacking carriage upholstery. Very varied are the material shown us: buffalo hides, morocco goat-skins, horse-hair seatings, velvet, woollen, and merino goods, and a roll of material some two thousand feet long waiting conversion into carriage rugs. Near at hand there is a shop where the Company's road stock is repaired, but we omit visiting it, and wend our way to the Coach Painters' Shop. The under frame of a new carriage is painted, but the body is varnished only, so as to bring out the natural grain of the wood. As a rule the first varnishing lasts about two years, when the carriage again undergoes similar treatment, the second varnishing lasting about another three years, but in time the sulphur-laden atmosphere of the great metropolis so discolours the wood as to render further varnishing ineffective, and the grain then hides itself for ever under a coat of brown paint. It may here be remarked, that on December 31, 1891, the average age of the Company's engines was 6·37 years, and of the carriages, 9·6.

We have now completed our tour of the Hudson Works, with the exception of the Laboratory, which we will notice on our return, and passing for safety's sake through a subway instead of crossing the lines, we emerge close to an oil-gas works which supplies light for some 1,200 carriages. The special feature of gas made from oil is that it possesses a very high illuminating power, and compared with coal-gas loses very little of it by compression, so that a cylinder six feet long by twenty inches diameter will carry a thirty-six hours' supply. It is stored in stationary holders at a pressure of twelve atmospheres, and is conveyed thence through underground pipes to the sidings, and delivered to the carriage cylinders by means of stand-pipes erected at convenient distances. Travelling holders convey the gas to such trains as can only be filled at out stations. Of course there are by-products from oil-gas making as from coal, and thereby hangs a tale. One of these by-products is a tar for which there was neither sale nor use, and it was consequently allowed to run to waste. Finding its way into the waters of the Channelsea and the Lea, its iridescent appearance and pungent aroma attracted the attention of the sanitary authorities, who, not appreciating its disinfecting qualities, considered it a nuisance calling for abatement. What to do with it now became a serious question, until, at the suggestion of the Chairman, the present Locomotive Superintendent, Mr. Holden, utilized it for fuel. Never was there a better exemplification of the saying that "Necessity is the mother of invention." The liquid fuel injector, designed originally with the sole object of using up this refuse, is now a feature of considerable interest in the engineering world. At Stratford it is applied to various uses, and we shall speak further of it when among the locomotives. We have now reached the new Wheel Shop, and watch the manufacture of carriage wheels. As a rule, these wheels have no spokes, but are built up solid of teak wood segments, care being taken to place segments of equal weight opposite each other, in order that the wheel may be properly balanced. When the tyres and axles have been forced on, the wheels are tested on a balancing machine, and any excess of

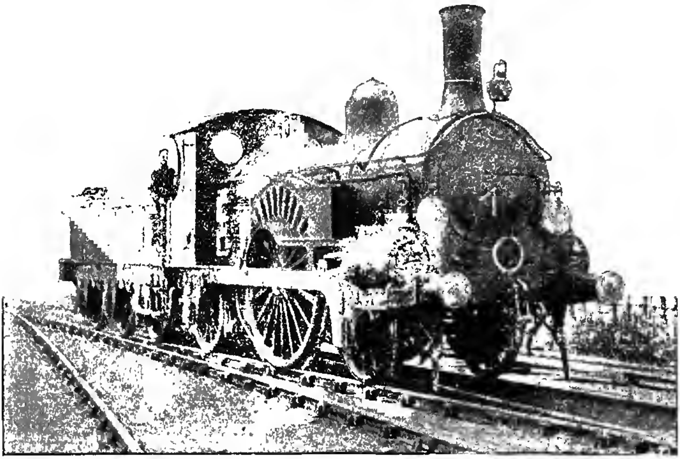


WHEEL SHOP.

weight in one part adjusted by an iron strip bolted on opposite. There is more in this than one might imagine, a pound or so too much or too little in any part of the wheel being enough to convert an otherwise comfortable carriage into a veritable "sea on land."

In the Wagon Department we get a good idea of the varieties of traffic for which the Company has to cater. For farm produce and general merchandise the ordinary goods wagons suffice, but these are totally unsuitable for heavy machinery, or, on the other hand, for eggs and light but bulky articles which come in large quantities from the Continent by the Parkeston route. Special wagons also are required for yeast, and for fruit, and for the American lard which comes by the Great Eastern route from Liverpool to London. As one particular traffic grows or another diminishes, modifications become necessary in the designs for new vehicles, but wherever practicable these are confined to the body, the under frame, which is now generally made of steel instead of wood, being kept to standard dimensions. The Wagon Department has its own saw-mills, smithy, and machine shop. We are shown a combination machine which will cross-cut a wood solebar to length, cut the tenons at either end, bore all necessary holes, and bore and chisel out the mortices. This is so ingenious and interesting that it seems a pity it will have to be disestablished and disendowed ere long by the all-conquering steel.

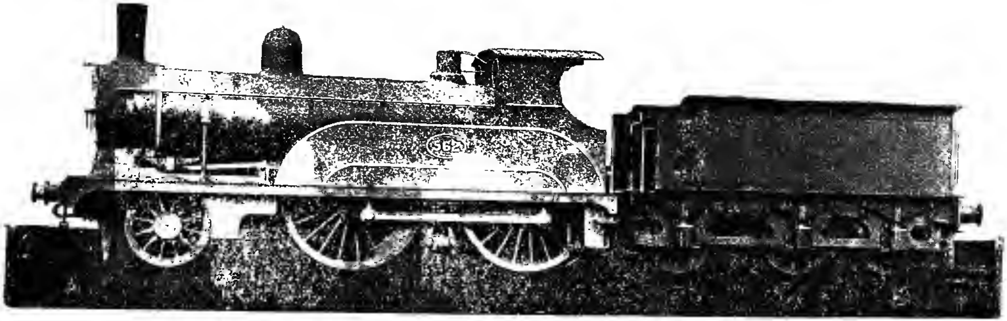
There are several shops close by the Wagon Department, including a tinsmiths', an engine paint shop, and a shop where the tender for the record engine was built, but a little further there is something that breaks the monotony of a round of manufacturing processes, and thither we hie. We refer to the Engine Stables. Here, if we may use the similitude, we see the heavy cart-horse, the more active cab-hack, and the well-groomed and carefully tended racing-steed, their life-blood swelling within them; and from the readiness with which they respond



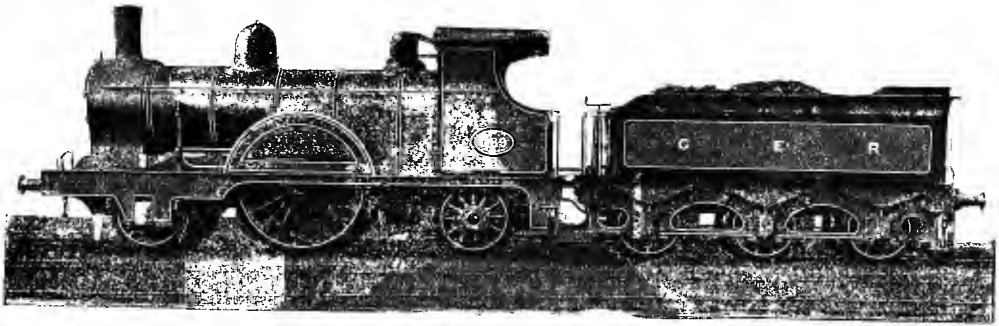
SINCLAIR'S EXPRESS, 1862.

to the touch of command, as proud, apparently, of their drivers as their drivers of them. And this is saying a good deal, for the love of an engineman for his locomotive is next to that of an affectionate man for his wife and family. It must not be imagined from this that most enginemen are celibates; on the contrary; and when we enter the smoking-room attached to the Dormitory, and remark that the occupants seem very comfortable, one of them lays down his paper and declaims vigorously against his enforced absence from home, due to the revised working and shortened hours adopted in consequence of the pressure put upon the companies by Parliament and the Press since the publication of the return called for by Lord Delawarr in 1887.

The Dormitory buildings consist of a kitchen, bathroom and lavatory, dining-room, smoking and reading-room, and a dormitory chamber containing thirty-eight separate cubicles. Each cubicle has a well-covered and comfortable bed, over the head of which there is an electric glow lamp regulable by the occupant. Within arm's length is a shelf on which there stands a water-bottle and a Bible. The whole of these buildings are lit by electricity, and although plainly furnished they are as clean and comfortable as could be wished. Underneath are the cleaners' rooms and a suite of offices; and to gain an idea of how much the engineman of to-day differs from his prototype of 1840—when the Eastern Counties Directors recorded that "the duties of engine-drivers are so simple that unwearied vigilance and watchfulness are almost the only qualities required,"—it is only necessary to walk into the room where the duty list is exhibited, and after careful study of the many notices and diagrams of working, enter for an examination as to their contents. These diagrams have been aptly described as "mysterious-looking sheets, covered with figures and with lines which zigzag all over their pages, requiring a special training to arrange them, and another special training to understand what they mean."

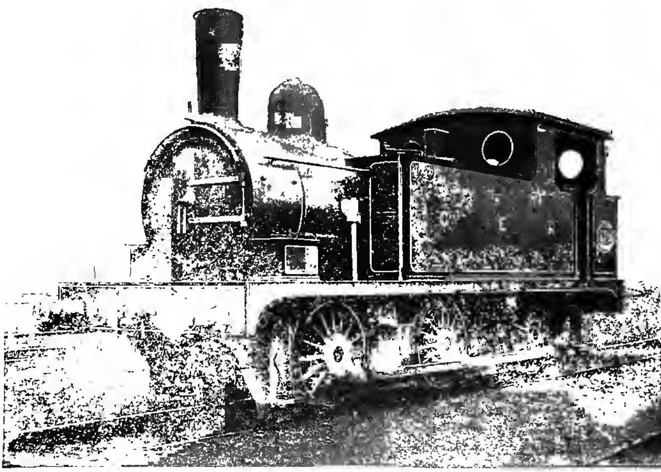


WORSDELL'S FOUR-COUPLED EXPRESS, 1882.



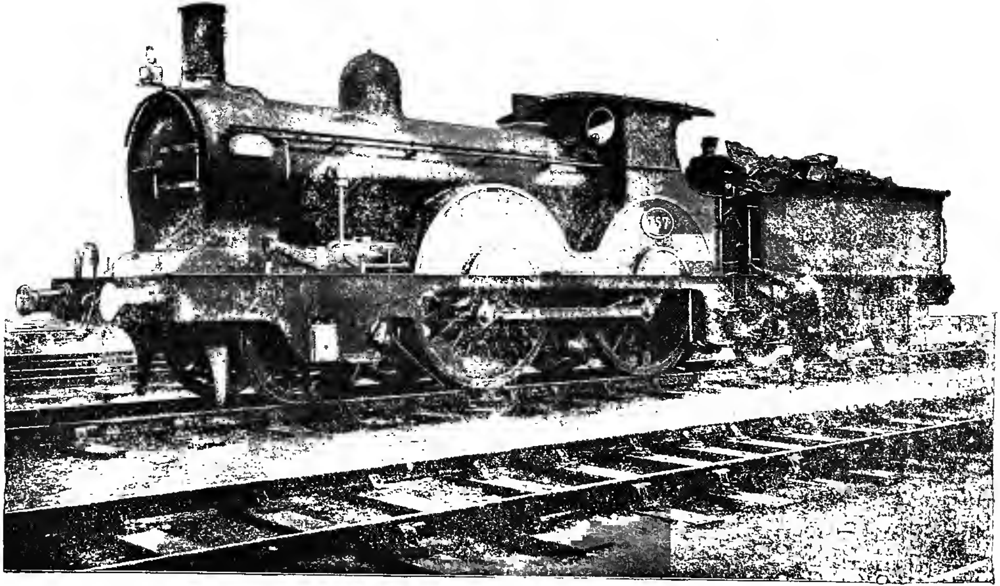
HOLDEN'S EXPRESS, 1888.

Leaving the offices we notice several huge stacks of coal, and asking how long the ten thousand tons they contain would last, are answered that the annual consumption throughout the line, if measured at forty cubic feet to the ton, would equal a column one hundred feet square, and three and a half times as high as St.



HOLDEN'S SIX-COUPLED TANK ENGINE.

Paul's Cathedral; whilst the water puffed into the atmosphere as steam would equal a river ten feet deep, twenty-five feet wide, and nearly eighty miles long. We are now conducted to the stages from which the engines are coaled, and witness the operation of putting some three tons of coal in a tender in less than five minutes. As the trucks arrive from the collieries, they are taken up an incline between two platforms, and at

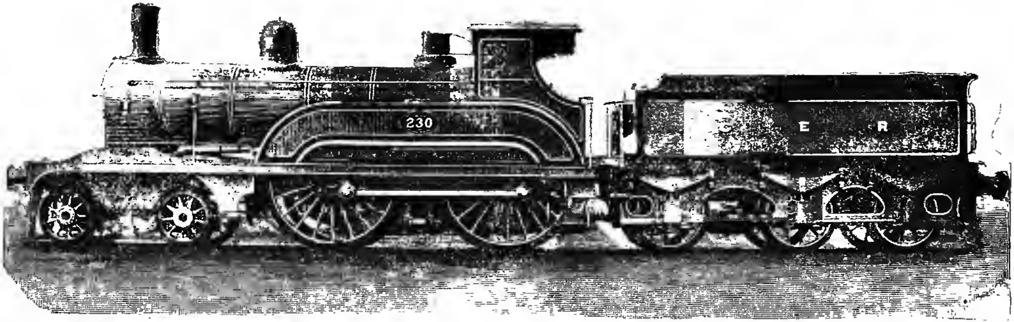


HOLDEN'S FOUR-COUPLED EXPRESS.

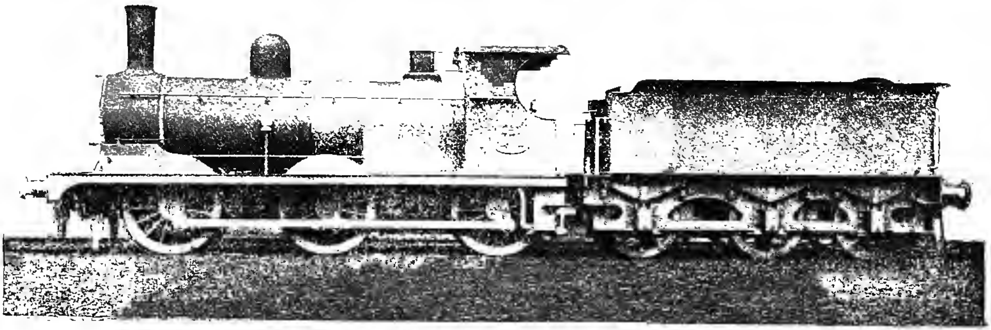
(From a photograph by W. M. Spooner & Co., Strand.)

once attacked by a set of grimy-looking men, who shovel the coal into iron trolleys, each of which holds ten hundredweight, and as fast as a truck is emptied it is run out of the way down an incline at the opposite end. The platform level is a little higher than the top of a tender, and when an engine comes up on one of the two outside roads, the trolleys are run on to an overhanging table which falls with the weight, and the door of the trolley opening automatically, the contents are shot into the tender. A careful record is kept of the coal consumed per mile by each engine, and premiums are awarded monthly to the driver and fireman of the most economical and best kept engine in their district.

A chat with the chief foreman of the Running Department leads to a mention of the various engines of which he has had control at one time or another, and gives an opportunity of jotting down a few particulars relating to some of them. The first engines built in Stratford Works were designed by the Locomotive Superintendent, Mr. J. V. Gooch (brother of the late Chairman of the Great Western Railway), in 1850. They were passenger tank engines, and had single driving wheels six feet six inches diameter, and outside cylinders twelve inches by twenty-two inches, and weighed in working order twenty-three tons. These engines were employed for express trains, and the water capacity being limited was in some instances supplemented by tanks carried under the brake vans. In 1859, Mr. Sinclair designed some four-wheel coupled (six feet diameter) goods tender engines, with outside

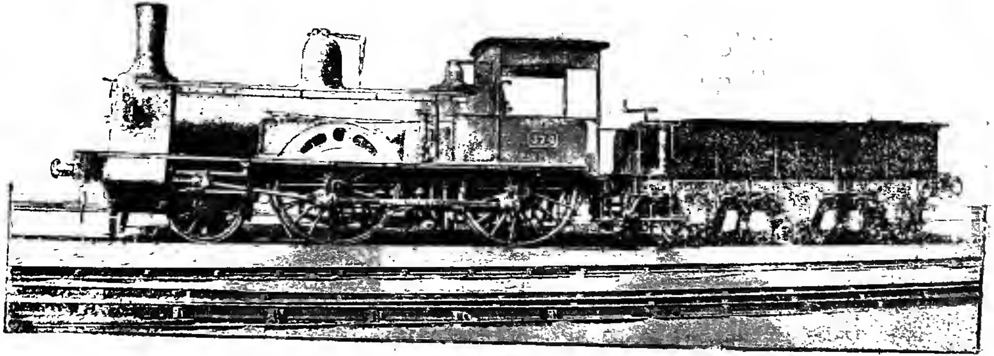


WORSDELL'S TWO-CYLINDER COMPOUND, 1884.

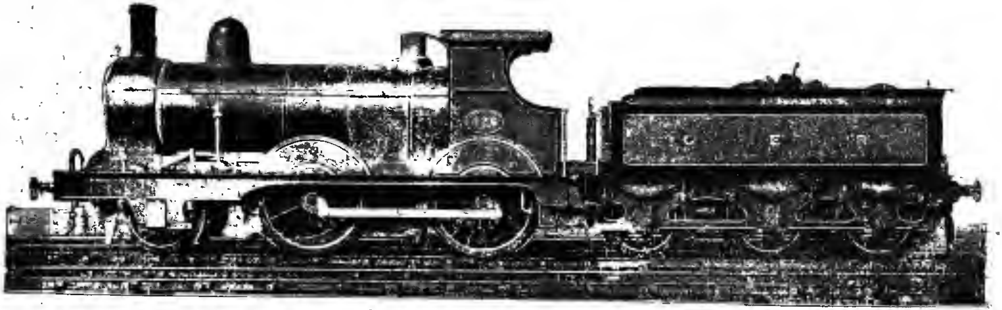

WORSDELL'S SIX-COUPLED GOODS ENGINE, 1883.

cylinders seventeen inches by twenty-four inches, weight in working order sixty tons; one of these (No. 327) was in the Exhibition of 1862. About the same time Mr. Sinclair also designed some single wheel (seven feet diameter), outside cylinder sixteen inches by twenty-four inches, passenger engines, weight in working order fifty-seven tons, somewhat similar to Gooch's, but with tenders in lieu of tanks. These engines, one of which (No. 284) was specially decorated for conveying the Prince and Princess of Wales to their new home at Sandringham whilst the wedding bells were gaily ringing, continued to work the chief expresses until about ten years ago, and six of them are still in running. As the suburban service grew, another class of engine became necessary, and Mr. Johnson, now Locomotive Superintendent of the Midland Railway, designed in 1873 some tank engines four-wheel coupled (five feet four inches diameter), inside cylinders seventeen inches by twenty-four inches, weight in working order forty-five tons; these are still in running, and one of them (No. 193) burns liquid fuel. In 1878, Mr. M. Bromley designed the single wheel (seven feet six inches), outside cylinder eighteen inches by twenty-four inches, passenger express engines, the weight of which in working order is seventy-six tons. All the foregoing engines, with the exception of Gooch's tanks, were purchased outside; but on the advent of Mr. T. W. Worsdell in 1882, this practice was discontinued, and every new engine since has been built at Stratford. Mr. Worsdell began with a four-wheel coupled (seven feet diameter), inside cylinder eighteen inches by twenty-four inches, passenger express engine (page 139), weight in working order seventy-seven tons, and then came his six-wheel coupled (four feet ten inches diameter), inside cylinder seventeen and a half inches by twenty-four inches, goods tender engine, weight in working order sixty-eight tons. These were followed by a two-cylinder compound bogie express, four-wheel coupled (seven feet diameter), one cylinder eighteen inches by twenty-four inches, and the other twenty-six inches by twenty-four inches, weight in working order seventy-seven tons. It is worthy of note, that the first compound locomotive of which there is any record was originated and tried on this line. It was a two-cylinder goods engine, compounded about the year 1848 from the ideas of a fitter named John Nicholson, employed at the Company's works; but although this engine was in running for some years, and experiments made with other engines also, little is known of their performances.

In 1886, Mr. J. Holden, the present Locomotive Superintendent, built some six-wheel coupled (four feet diameter), inside cylinders sixteen and a half inches by twenty-two inches, tank engines (page 140), weight in working order forty tons, for suburban passenger and local goods trains, and followed on with some four-wheel coupled (seven feet diameter) express tender engines, given below, cylinders eighteen inches by twenty-four inches, weight in working order sixty-five tons. A special feature of these engines is that the cylinders are cast in one, with the slide valves working below, so as to ensure better lubrication. One of these, "Petrolea," is fitted to burn liquid fuel, but beyond the addition of an oil-tank on the tender, and a few pipes leading to the injectors below the fire-hole door, there is nothing in its outward appearance to distinguish it from a coal-burning locomotive, to which indeed it can be converted at any moment, there being no alteration in the construction of the fire-box. A special feature of the injector is an outer ring through which jets of steam pass, these jets impinging at the nozzle on the liquid fuel induced through a central cone, and breaking the fuel up into a very finely divided spray which ignites immediately. There is a passage in the injector through which air also is induced, and as the emission of steam, liquid, and air can be adjusted independently of each other, combustion is regulated to a nicety, and the slightest suspicion of smoke avoided. The fire is lit up with coal in the usual way, and a bed of incandescent fuel and chalk or broken bricks kept up, the weight of coal used in conjunction with the liquid fuel being about one-third of the total fuel consumed. It can be readily imagined what a saving of labour this is to the fireman, whilst the incandescent base enables the engine to lie practically inert for hours if required, yet ready to start into action directly the injector is worked. "Petrolea" is engaged regularly on heavy express trains, and having a striking appearance is an object of much interest to the crowds of people swarming Liverpool Street Station—the busiest terminus in the world. Another of Mr. Holden's engines is No. 789, shown on page 139. There are at present eleven of this design, which is similar to the 760 class, but with single instead of coupled wheels. They have been specially built for long journey fast trains, and are



SINCLAIR'S FOUR-COUPLED PASSENGER ENGINE, 1859.

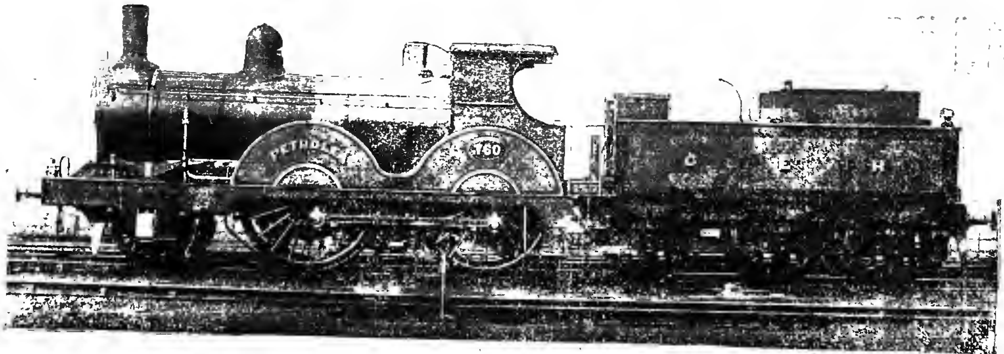


HOLDEN'S MIXED TRAFFIC ENGINE, 1891.

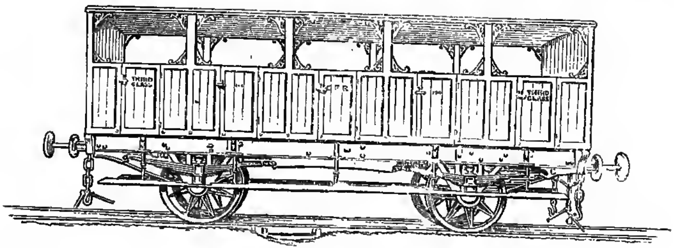
engaged chiefly on the London and York service. Still another variation of the 760 class is the 420 class (page 147), four-wheel coupled (five feet eight inches diameter), cylinders seventeen and a half inches by twenty-four inches, weight in working order seventy-one tons, designed for use either as passenger or goods engines. Almost all details of these three classes are interchangeable, a point of much greater importance than the general reader would suppose, and a very different state of affairs to that existing a quarter of a century back, when, we are told, there were in the repairing shop on one occasion forty engines, of which hardly a single part of one was interchangeable with that of another!

Returning to the works, we are shown a hydraulic testing machine registering from twenty pounds to fifty tons, and are then conducted to the Laboratory, which consists of an office and consulting-rooms, a balance room, the laboratory proper, and an operating room, containing metallurgical appliances and a stock of commercial chemicals. Many, we learn, are the duties a railway chemist is called upon to perform: testing milk for the hotel department, or new explosives which the goods department is called upon to carry; reporting upon samples of water suggested for drinking at different points on the line; whilst in connection with the locomotive department the percentage of carbon in a steel plate or arsenic in a copper plate has to be ascertained, the calorific value of fuels determined, and doubtful stores to be analyzed for suspected adulterations.

As regards the social aspects, there is an Accident Fund, to which each of the 5,260 workmen subscribes, a



HOLDEN'S LIQUID FUEL EXPRESS ENGINE, 1886.



OLD THIRD CLASS CARRIAGE.

Pension Fund and a Savings Bank, optional, and a Contagious Diseases Fund. The institution of the three former is due to the present well-beloved Chairman; the latter is a workmen's movement entirely, and an excellent one, not only preventing the deprivation of the member's means of support when most needed, but by removing the risk involved in coming to work when disease is in their homes, preventing the spread of infection amongst their shopmates. The Company covers every subscription to the Accident Fund and Pension Fund with an equal amount, gives four per cent. interest on Savings Bank investments, and supports a Science and Art Institute and Technical School situated near the works, which has a library of nearly 7,000 volumes. Last, but by no means least, every person in the Company's employ has the right to travel once a week, with any members of his family residing with and dependent upon him, to any point on the system at a fare of a farthing a mile.

CHAPTER VI.

THE GREAT WESTERN RAILWAY WORKS AT SWINDON.[1]

BY A. H. MALAN,

[With Illustrations from Photographs by the Writer.]

THE ordinary individual, with little more than a smattering of mechanical knowledge, who should essay to "do" any large railway works, and expect to come away with the construction of engines or carriages at his fingers' ends, would be likely to be more or less mistaken. For what between the heated forges, thumping steam hammers, whirring lathes, and deafening riveting sheds, a casual visitor is lucky to escape with only a slight headache, and may consider himself fortunate if he carries away an intelligent perception of the working of some few of the more interesting machines. So it is with Swindon, the nursery and hospital of the Great Western rolling stock.

But as one wanders round from shop to shop, bewildered and inquisitive, two points at least seem to impress themselves upon the mind :—

[1] This paper has no pretence to be an exhaustive description of these large Works, but is merely the impression of them gained by a visitor, who is much indebted to Mr. Dean's courtesy.—A. H. M.

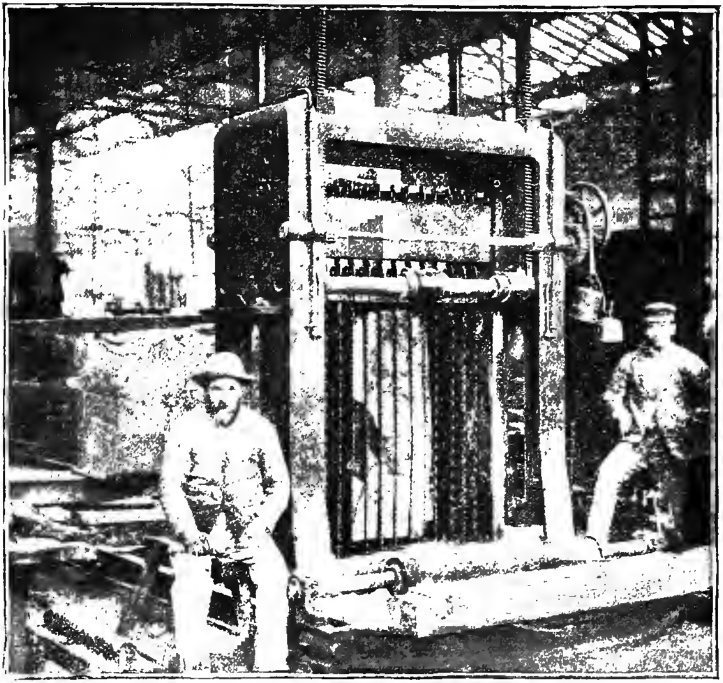
(1) The economy of mechanical power, through duplication of work; and

(2) The giant forces, invisible and unsuspected, literally beneath the feet, only requiring the touch of a handle to exert tremendous power in divers ways and methods.

This duplication of work is seen, for example, in the cutting out of iron plates, in the boring therein of rivet-holes, in the sawing of timber, and I know not what else besides. Just as a pair of scissors can cut a dozen folds of paper as easily as a single sheet, so a colossal machine here cuts through a pile of frame plates (each plate ranging from three-quarters to one inch thick) at one operation, thereby saving both time and mechanical wear and tear, and producing plates absolutely identical; while other machines subsequently bore all the holes needed, with their multiple drills. Great trunks of oak and teak are also operated upon in a similarly wholesale fashion; large saws, fastened side by side so as to be actuated simultaneously, converting a balk quickly into so many planks of any required thickness.

Perhaps the wood-working department—a veritable variety shop of industries—is the most captivating part of the whole works; and none the less so on account of the resinous, turpentiny smell, which is deliciously fragrant and refreshing, as compared with the oily atmosphere of most of the other buildings. Here is one man turning elliptical pick handles; another cutting out, by means of a band-saw, ovals and rounded parallelograms, for the moulded decoration of the carriage interiors; while a third attends to the machine which does the moulding in the pieces of board previously perforated.

And what a wonderful machine that is! Imagine an iron table with nothing upon it but one solitary steel spindle, standing up like a ninepin. The piece to be

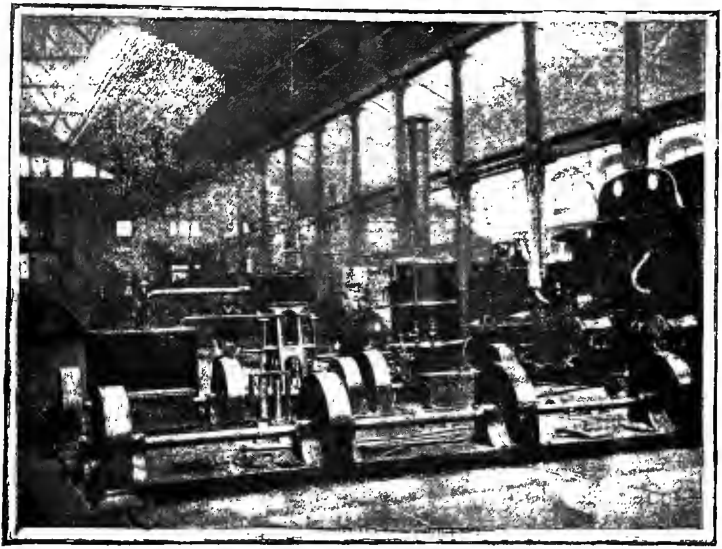


LOG FRAME SAWING MACHINE.

moulded is laid flat on the table, its edge pressed and pushed along against the ninepin, and behold, from the shavings and saw-dust flying round in a whirlwind, it transpires that the innocent-looking spindle is really a most formidable tool, revolving at incredible speed, its cutter being the exact counterpart of the mould to be produced. Whether it works *with* the grain or *against* the grain, makes no difference to this machine, the resulting mould proving to be, throughout all its parts, equally true, smooth, and uniform. That this moulded work is of mahogany is not surprising, considering that it is intended for ornamentation; but what is rather surprising is, that some of the other wood-work, which is not moulded, and which in its finished state will be covered with paint, is made of mahogany also. So lavish seems to be the use of this material, that even the outside panels of the carriages below the windows are made of it; inferior wood appears to be nothing accounted of, even as in the days of Solomon.

On passing from this department, the gates of a long building opposite happened to swing open, and there emerged into the light of day the queerest locomotive that ever was built! This proved to be an engine-traversing table, the function of which is to receive upon its platform a disabled engine (run on to it, as on to a turntable), and transfer it broadside within the repairing shed, ridding itself of its burden at one of the many rails running at right angles to the central lines on which it travels; or, again, to pick up, from a batch of cripples, some convalescent engine, and bring it once more into communication with the permanent way. In the right hand of the print the tail-end of an engine is seen, ready to be placed on the table.

In the carriage works much care is seen to be exercised over the safety and comfort of the public. Here, for instance, is a machine for testing spiral springs. If a spring were to snap, when a train was running at speed, a carriage might be derailed. Every precaution is taken that this shall not occur. In goes a spring to be tested, down comes an hydraulic ram, pressing down the spiral



ENGINE-TRAVERSING TABLE.

coil at one thrust, and recording on its gauge the pressure exerted—in other words, the weight and strain which the spring, if called upon, might sustain without detriment.

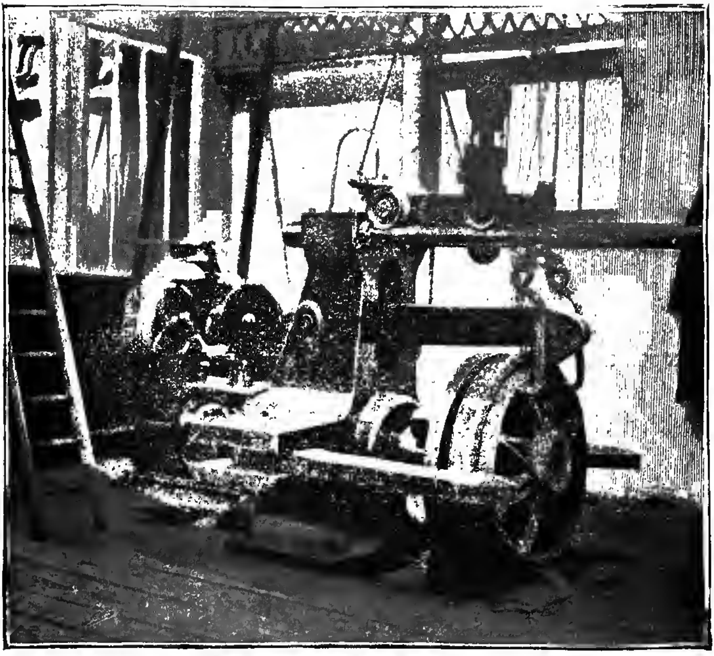
In another machine laminated springs are tested in the same way; the bow of a spring being straightened out, allowed to resume its normal shape, and straightened out again, as though it was fashioned of laths of willow.[1]

Then, again, those buffer-guides, which appear to be simply of cast iron as one looks at them attached to the carriage-ends, are by experience found to be more reliable and durable when constructed of wrought iron, and accordingly of wrought iron they are made. Thus: three pieces of iron plate are punched out to form the top, bottom, and middle part, and these, when brought to a welding heat, are placed in their relative positions in hydraulic press doing the duties both of hammer and mould, and after one or two operations the finished article is turned out, without any trace of joining, and apparently a single forging. To see these made, we resort to the forges; and while we are in that direction a far more elaborate example of welding and building up is met with in the case of engine and truck wheels. These, in their earlier stages, consist of several sections which are stamped out in dies under the steam hammer. One section forms a segment of the rim and outer part of the spoke; another, which is stamped in duplicate and sawn by a circular saw, gives the inner half of the spoke and segment of the centre. The two sections being then welded together, are ready to be framed for receiving the washers which form the boss. They are temporarily held together by an iron hoop, and after being brought to a white heat at the centre, are placed under the bossing hammer; a white-hot washer is then

[1] The power required to straighten the larger laminated springs for wagons and carriages is about seven tons; that for compressing spiral springs about five tons.

placed on the centre, to be securely fixed by one mighty thump of the hammer ; another washer is welded on the other side, and the boss is complete. The spaces left in the wheel rim are filled up, and welded, while at white heat, by a hydraulic press technically known as a "Veeing" machine. The whole operation presents a most picturesque appearance. The men standing round the hammer, with one dazzling spot in their midst, their outlines thrown into highest relief by the strong glare from the neighbouring forges, pose themselves naturally, and produce an excellent Rembrandtesque effect. Indeed the forge-light is so bright that, with some consideration and arrangement, a satisfactory photograph of the scene would be perfectly possible, with but a moderate exposure.

The carriage wheels, too, are constructed especially with a view to minimum of noise and dust, and maximum of smoothness of motion ; and these desirable features in railway travelling are partly secured by the portion of the wheels, where the spokes would otherwise be, being a solid disc of teak, built up of triangular blocks around a cast-iron centre, with the tyres bolted thereto. The way these wheels are secured on their axles is both simple and ingenious. First, the ends of the axle-shaft are turned perfectly true and parallel, the portions where the wheels will be fixed being slightly larger in diameter than the bore in the centre of the wheels ; and to ensure this being done as accurately as possible, the callipers which serve as a gauge are themselves tested once a week. Then, two wheels having been passed over the ends of the shaft (previously smeared with oil and white lead), the pistons of two hydraulic presses are applied, which pistons, working towards each other, press the wheels towards the centre of the shaft. And usually



HYDRAULIC WHEEL PRESS ARRANGED WITH FACE PLATE FOR PULLING TYRES OFF WHEELS.

when the wheels are found to be at exactly the correct interval apart for the metals of the permanent way, the needles on the gauges indicate a pressure of seventy tons. Near by is a similar kind of press adapted for breaking off *riveted* tyres from truck-wheels that have served their time, or need repairs. In this case the wheel is fixed in such a position as to have the tyre grasped by four projecting arms attached to the body of the press, and then a ram, capable of working up to four hundred tons, is set to work noiselessly and at first imperceptibly; in a few seconds, however, a loud report is followed by the wheel falling down, the tyre remaining suspended, the rivets having been sheared in half between the inside of the tyre and the outside of the wheel-rim.[1]

To see these and the thousand and one other operations, the sum total of which result in the construction, or repair, or demolition of rolling stock, we are taken here and there, through gloomy un-roomy forges, and vast well-lighted buildings (some of them seven hundred feet long), endeavouring, as we proceed, to absorb some few grains of knowledge from the full measure of information supplied by our cicerone; replying to the instructive description of the varied and various machinery with a kind of dumb show, since no small degree of caution is required by a stranger wishing to steer clear of the red-hot sparks, revolving wheels, and ubiquitous oscillating arms; and the air is too full of many noises to admit of intelligible conversation.

Noise, indeed, there is more or less everywhere throughout this busy hive; but the finest effects of genuine ear-splitting clatter are naturally met with in the riveting shops. Hydraulic riveters—so nicely balanced, and easily moved, that a little child might guide them—do

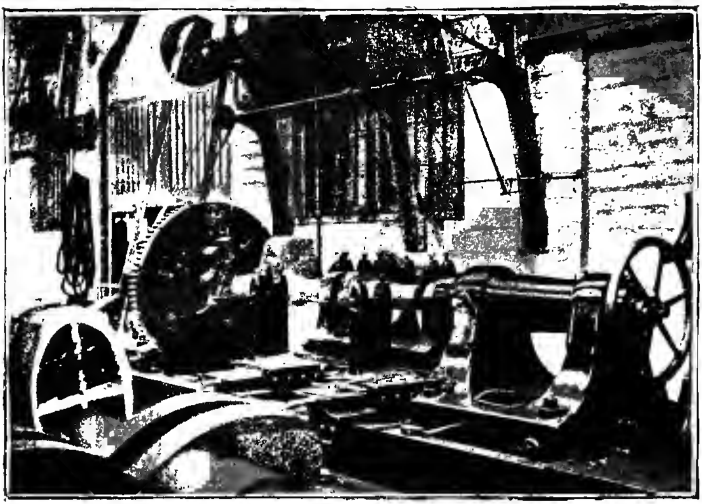
[1] Usually when the tyres burst their bonds the needle shows a pressure of sixty or seventy tons; but in some cases it reaches as high as one hundred and fifty tons.

all the work within their reach ; and very prettily they do it, just giving one noiseless "squelch" with their great crab-like callipers upon the red-hot iron, and leaving a neatly-shaped head where the long exposed end of the rivet previously protruded. But where these silent workers cannot operate, for lack of space or other reason, there *human* riveters are in all their glory ; showing their appreciation of the pandemonium they create, by performing merry rataplans with their hammers at every moment of waiting. It is sad to think these men seem all doomed to be deaf; but on the whole this appears certainly a more merciful dispensation than if they were doomed to retain the faculty of hearing unimpaired.

It would be a truly herculean task to count all the lathes scattered over works which employ upwards of nine thousand men. But the bulk of the lathes being congregated in the great fitting and turning shop (known as the R shop), by resorting thither we can get a general idea of the class of work done by these machines. It being the dinner hour when we entered, every wheel was at rest, and the grip of many vices relaxed. But scanning from the foreman's office window the area below, with evidences of the highest mechanical ingenuity spread before the eyes, it seemed plain enough that those who pass their time in such pursuits as these have many tangible advantages over Hodge the labourer and cousin Jacky the miner.

Here "the pale mechanic" by no means pores over his lathe, with bent shoulders, contracted chest, and anxious gaze absorbed in the tool-point. He simply sets the machine at which he is posted upon a piece of work, sees that the cutter or borer or planing tool is doing its duty, and then leaves it to work its own sweet will till the task is completed, when he proceeds to provide it with fresh material.

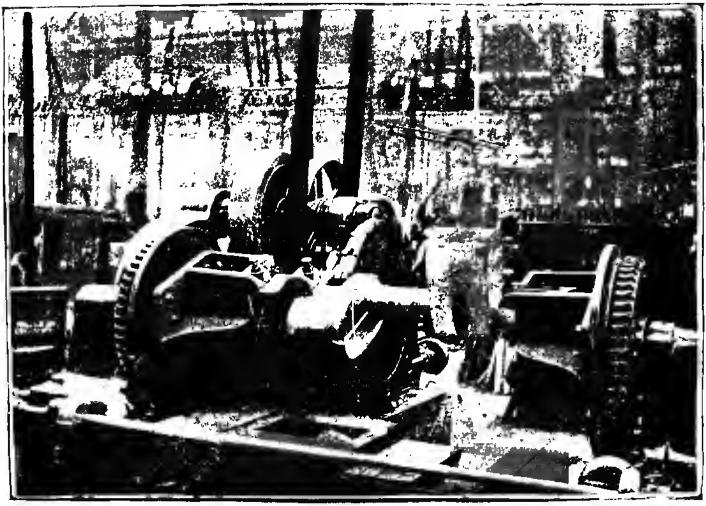
There may be monotony in this, as in most forms of



LATHE FOR TURNING LOCOMOTIVE CRANK AXLES. BED TWENTY-FIVE FEET LONG, HEAD STOCKS TWO FEET SIX AND A HALF INCHES. SIX TOOLS.

labour ; but at least such an artisan is constantly knocking against other men engaged in other departments ; the work going on around him is calculated to make him *think ;* and if he sees fit to improve his mind or learn drawing, there are books in plenty in the Institute, and science and art classes well within his reach. Possibly he may not after all prove to be such a good all-round man, or such a desirable engineer for a steamer, as a fitter who has served in a small foundry, and practically gone the round of *all* the shops; but while railways continue and machines to turn out the different items in their construction need men to tend them, his wages are sure, and he can always count upon a free Sunday as well as a weekly half-holiday.

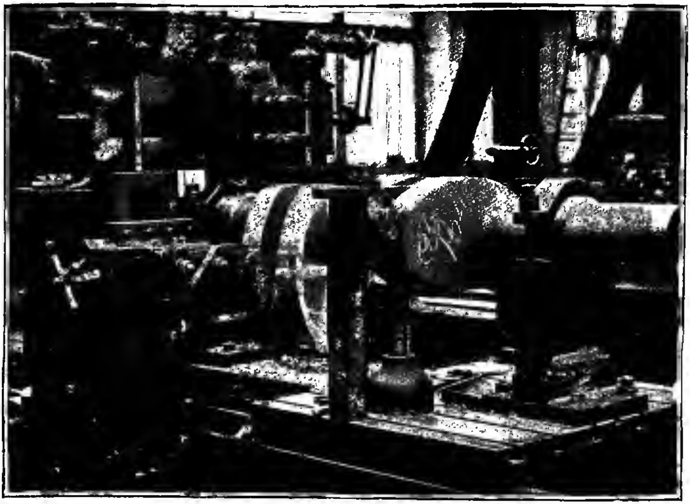
Many objects attract attention in this exhibition of mechanics, but space only permits reference to one or two. Near the foreman's office, for instance, there catches the eye a compact machine apparently in the act of smoothing the crowns and sewing on the ribbons of four white straw hats, symmetrically arranged on a little rest at each corner. These hats are bosses for wood wheels, and are manipulated by one cutter working on the outside, while another accurately finishes the rough-boring of the hole for the axle. A little way off are a series of lathes for equipping engine-cranks. The first of this series turns a crank at all parts of its length except where the crank-pins are to be. In this case the crank-shaft revolves, and the tools, six in number, are stationary. The next is for cutting out and shaping the crank-pins themselves, which are to be embraced by the brasses of the big ends of the connecting rods, and require to be turned to the highest degree of trueness and smoothness. In this case the crank-shaft being stationary, the work is performed by cutters fixed in a revolving disc. The space, which is observed already removed in the right-hand crank, is cut to a sufficient depth by the disc advancing while it rotates. After this operation is completed, the crank is caused to revolve slowly on the axis indicated by the intersection of the chalk lines (clearly shown on the left-hand crank), while the cutters, revolving at the same time, cut out a cylindrical crank-pin. To finish the pins, the crank is transferred to another



LATHE FOR TURNING CRANK-PINS.

machine, in which a cutter, revolving round the pin, imparts thereto a perfectly true and smooth surface. But even so the cranks are not finished, for the crank-webs have to be cut to the requisite curve. This is done by yet another machine, the ingenious tool of which, while moving to and fro, and cutting both in its forward and backward path, follows the slotted curve seen at the left of the print, and thus effects the required shape in the crank-web.

Here, too, new cylinders were being bored out—in pairs, side by side, like gun-barrels; affording a fair illustration of that cramped arrangement of machinery, simply unavoidable in narrow gauge engines with inside



PLANING MACHINE FOR FINISHING CRANK-WEBS.

cylinders, which is of course obviated in the broad-gauge. If a new gauge were to be instituted throughout the country now, that gauge might not be seven feet, but it is fairly certain it would not be four feet eight and a half inches. Let a broad gauge "eight-foot single" and a modern narrow gauge engine be viewed from opposite their driving wheels, and both appear equally imposing objects; but let a front view be taken of them from between the rails, and then the one stands up, well proportioned to the base of support, and rests with all stability upon the seven-foot way[1]; while the other

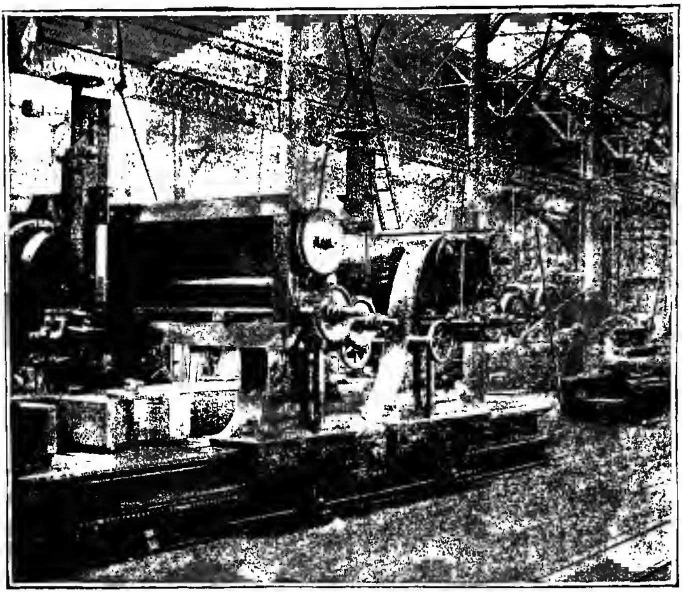
LATHE FOR LARGE LOCOMOTIVE WHEELS.

seems to protest, top-heavily, at being squeezed in

[1] To give but one instance of broad gauge stability—The "Prometheus," after running at full speed (in a dense fog) into a Bathstone train backing to meet it, did not even leave the rails. Huge blocks of stone were suddenly shot out of the wagons by the force of the impact. A narrow gauge train ran into a truck, at twenty-five miles an hour only, on that occasion; the narrow gauge carriages had their wheels in the air, when the fog permitted them to be seen at side of the line next morning.

between the hard and fast limits of a *too* narrow gauge.[1]

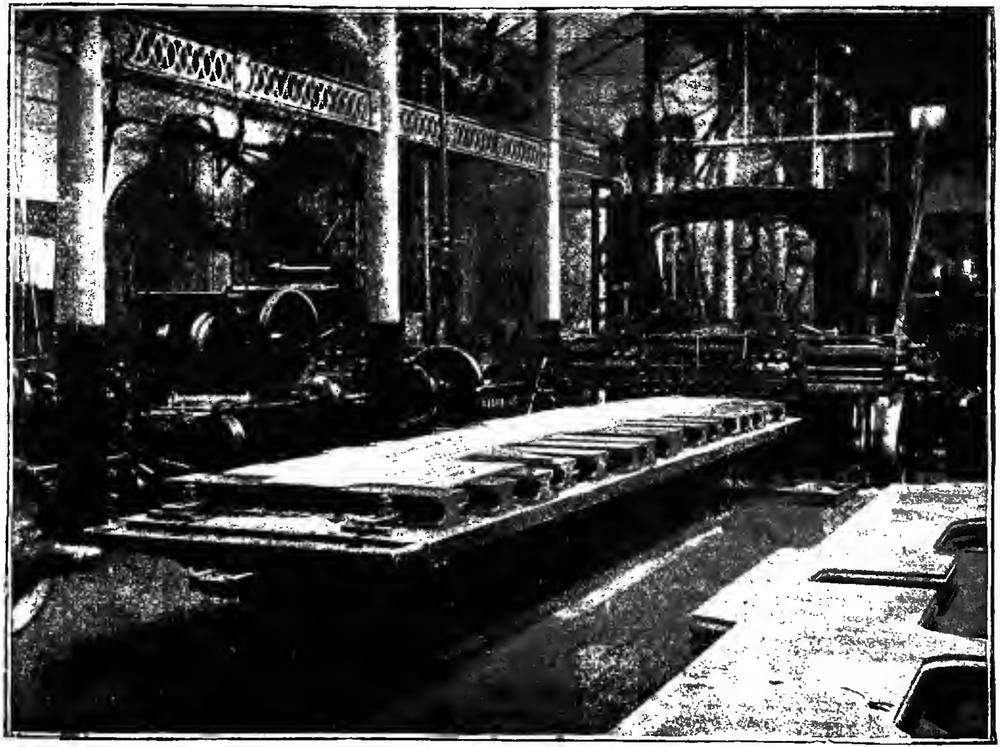
Were we to make an arbitrary classification of the



FRAME-PLATE SLOTTING MACHINE, WITH THREE MOVABLE HEADS, WILL CUT THROUGH TWELVE PLATES, EACH THREE-QUARTERS TO ONE INCH THICK.

large machines, it would perhaps be into those which are

[1] The *Railway World*, May 1893, well observes—"Looking at this powerful engine ('Bulkeley') from the front, one cannot help being struck by the enormous capacity which the seven-feet gauge allowed in the direction of boiler-room, for even in the Bulkeley there seems a wide gap between boiler-sheeting and engine-frame, whilst on many of the standard gauge engines the frame seems almost to form an extension sideways of the boiler-plate."



FRAME-PLATE PLANING MACHINE.

remarkable for the cleverness of their action, and those which strike one with their smoothness of motion. Of the former division an excellent illustration is met with in the curvilinear wheel-slotting machine. Obviously the inside surface of a wheel-rim cannot be turned, as one would turn a solid disc (*i. e.* by revolving the whole wheel), because the spokes would be in the way; hence the need of some other arrangement. But the almost human sagacity with which the tool in this machine does its work must be seen to be appreciated; raising the fore-part of its body upwards, and nibbling its way downwards, and repeating the same tactics in measured cadence, absurdly like some great hawk-moth caterpillar intently engaged upon a leaf. Among the latter division might well be placed the great plate-planing machine in V shop, where the whole frame-plate travels on its bed so evenly, that throughout its length of thirty feet every inequality on its surface is uniformly removed. Also the big lathes for turning the rims of the engine wheels, and boring the inside of their tyres. A lathe that will tackle an eight-foot driving wheel, and turn its rim perfectly true, or bore its tyre by shaving off shreds of metal no thicker than paper—not, be it observed, while the wheel or the tyre is spinning round, but only making, say, two revolutions per minute—can assuredly neither "wobble" much, nor be in any way loose in any of its parts.

In anticipation of the change of gauge on May 20—a day to be marked with the blackest charcoal by all good friends of the broad gauge—arrangements are already perfected for changing a carriage from broad to narrow gauge within the space of *half-an-hour!* The bodies and frames of many of the carriages, at present running on broad gauge rails, being already of narrow

IN THE CARRIAGE-BUILDING SHOP.

gauge dimensions, it will suffice to substitute narrow gauge bogies for those now in use. This will be effected as follows:—The carriages will be run into the changing shed in batches of about half-a-dozen; the floor of the shed, at the parts where the wheels rest, being capable of rising and falling. Arrived at their proper position, the bodies of the carriages will be raised clear of their bogie-frames by hydraulic power, and propped up so as to stand upon the supports when the wheels are removed, and then the platforms, bearing the broad gauge bogies, having been lowered beneath the level of the floor, the bogies will be run underground to the contiguous pair of rails, elevated to the line-level, and run out of the shed. Pairs of narrow gauge bogies will be then brought in on to the platforms, which will again sink under the floor, and pass up under the carriages; the whole being performed by hydraulic power.

This arrangement, the clever invention of some of the heads at Swindon, well illustrates the wide range of use within the capability of that water-pressure, which appears to be here utilized nearly to the same extent as steam; and serves also to show the ability of the staff to grapple with great undertakings.

CHAPTER VII.[1]

THE OLD BROAD GAUGE ENGINES AND THEIR SUCCESSORS.

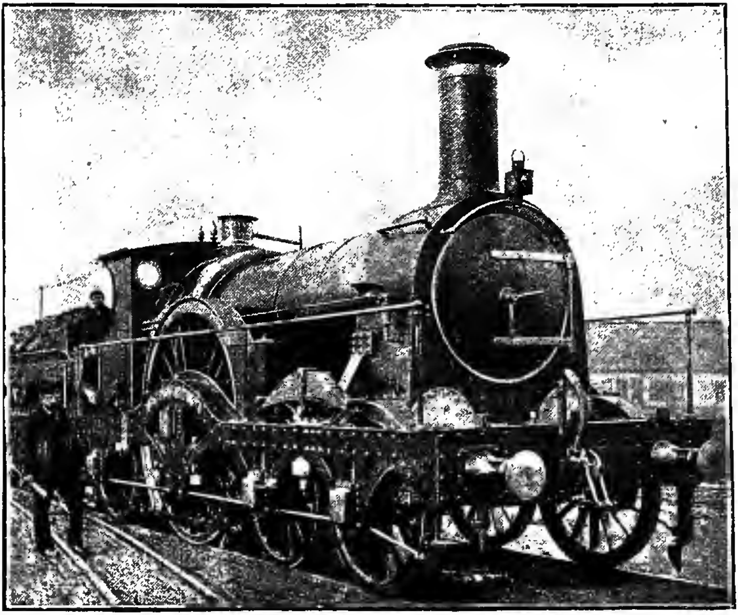
By A. H. MALAN.

It is improbable that any width between the rails other than that which goes by the name of the narrow gauge would ever have been adopted by any important English Company, had it not been for Mr. Brunel. Upon the proposal that a railway from London to Bristol should be constructed—one, as it then appeared, likely to be quite independent of other lines—Mr. Brunel, the engineer to the new Company, came to the conclusion that the ordinary tramway gauge was, for railway purposes, not so desirable as might be. He foresaw that the tendency would be towards increased speed, and that increased speed would necessitate more powerful engines; while he rightly judged that if ample width of support were given, not only would such engines have more room for the free play of their machinery, and the safety and comfort of passengers be more assured, but also that if a seven-feet gauge were adopted, any future contingencies of development in

[1] The portion of this chapter dealing with "Broad Gauge Engines," written shortly before the narrow gauge became universal, is reprinted as an interesting reminiscence in spite of its seeming anachronisms.

regard to size of wheels and carriages would be provided against in advance. He also considered that smoothness of motion would be increased if the rails were laid upon continuous longitudinal sleepers, instead of being supported only at intervals, as had hitherto been done.

These features in Mr. Brunel's scheme, though great innovations, and considerably raising the primary cost of construction above that of an ordinary line, yet were accepted by the Directors, who thought that the first-class traffic would certainly increase as the public became aware of the extra speed of the new departure. Possibly, also, to some extent they were influenced by the personal authority of their engineer. For in Mr. Brunel they found a man who both knew his own mind, and had a way of forcing his convictions upon others. It is plain, from his "Correspondence," that he was not given to brook much interference. He says, "A Board of Directors has a perfect right to dispense with the services of an engineer, but if they wish to have my personal advice and responsibility, they must place confidence in me, and must act as if they assumed that I was more able to advise the Board upon the practical questions of engineering than any one of the Directors." And this agrees with the outside opinion held upon this remarkable man. "It may seem strange to men of a younger generation that he should thus have been able to impose his ideas on the Legislature and the public alike; but to those who can recall the period of his fame, it is no matter for surprise. Few men have possessed such a power of inspiring others with an ardent faith in their schemes as was commanded by Isambard Brunel." For many years together the belief reposed by a large portion of the commercial world in this Napoleonic engineer and his undertakings verged upon the superstitious. Nor was it in the main "misplaced." And so Mr. Brunel had his way, and matters proceeded. Want

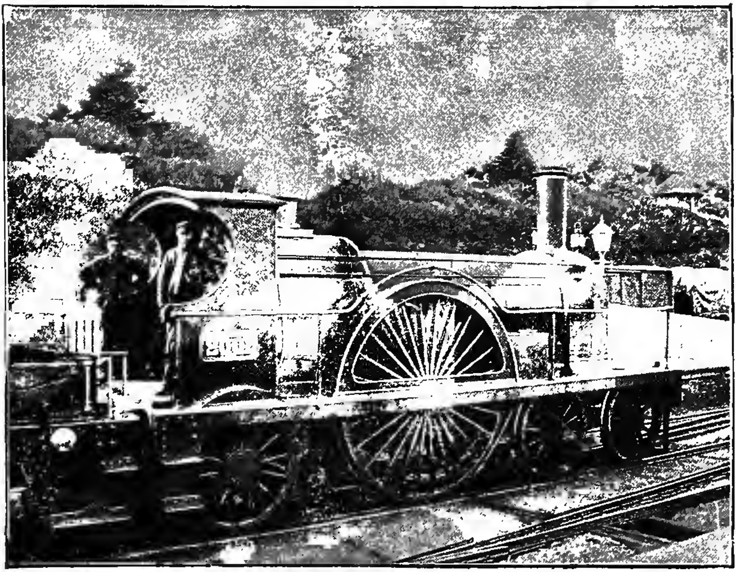


"ROVER." TAKEN AT BRISTOL BEFORE JOINING THE "DUTCHMAN," NOVEMBER 5, 1890. ("LORD OF THE ISLES" CLASS.)

of funds, however, prevented the line being made continuously from London to Bristol, and accordingly Parliament was, in 1834, asked to grant permission for the work to be begun by two disjointed sections—from London to Reading, and from Bath to Bristol. To this suggestion the Commons consented, but the Lords objected, it being said among other things, that the project would be a head and tail without a body, neither Great nor Western, nor even a railway, but a fraud and deception upon the public. The following year, however, the Bill passed, and by 1838 the line was open from Paddington to Maidenhead, and the broad gauge became a tentative experiment. The first engine at work was the "Vulcan" (8 feet single drivers, cylinders 14 in. diameter, 16 in. stroke), which made its first trip January 9th, 1838. The "North Star" began its duties a week later. Soon trouble began to be experienced with the permanent way, as both timbers and rails were found to be too small in section for the weight and speed of the trains, and certain shareholders looking askance at the cost of construction, the Directors requested two independent engineers (Mr. N. Wood and Mr. Hawkshaw) to inspect the piece of line in question. The report was somewhat unfavourable, but it was overruled by Mr. Brunel's reply, and in the following year the Directors told their shareholders that "they unanimously acquiesced in retaining the width of gauge with the continuous bearings, as most conducive to the interests of the Company," but added that "heavier rails and longitudinals should in future be employed." Thus the broad gauge became an established fact.

By 1840 the line was continued to Reading, and, operations having been carried on simultaneously at the other end, in 1841 it was complete to Bristol, affording a piece of road eminently suited for high speed, with curves of large radius, and no gradient steeper than 1 in 660 except two inclines of 1 in 100, on which additional engine power was to be used.

At this date the difficulty in running at a great speed lay not so much in the engines as in the primitive signalling arrangements. An average of thirty-three



BRISTOL AND EXETER ENGINE. RIGID FRAMING. EIGHT FEET DRIVING WHEELS.

miles an hour was about the best performance possible until the electric telegraph was matured in 1844, when the Great Western at once went ahead. From the first the broad gauge stood alone, with enormous odds against its adoption by other Companies, while its own ramifications soon began to upset the preconceived idea that, as a railway, it would be independent of other lines. Branching out boldly to the north, it came into competition for goods traffic with the London and Birmingham line, when the conflicting interests proved formidable enough to demand a Royal Commission to consider the matter. To the question whether break of gauge was an inconvenience requiring legislative control, the Commission reported, in 1846, that the narrow gauge was preferable for general convenience, and that if it were imperative to produce uniformity, it should be obtained by altering the broad to the narrow gauge, and not *vice versâ;* though it was also very justly remarked, that on the Great Western the motion was generally more easy at high velocities, and that in respect of speed, the advantages were also with the same Company. The Board of Trade could not, taking all the bearings of the dispute, see their way to recommend that the Great Western should be narrowed throughout, nor that a mixed gauge should be added over all their rails, and accordingly it appeared to Parliament that the case would be met by passing an Act to the effect that no new railways should be made in England otherwise than of 4 ft. 8½ in. gauge. This decision, coming as it did just at a time when great activity was being shown in the railway world, was virtually the death-blow of the broad gauge; although shortly after a strong request from Birmingham, that a contemplated line from Oxford thereto might be broad gauge, brought about another Act in 1848 authorizing the proposed extension. Meanwhile, however, narrow gauge lines had been increasing throughout the Midlands, and the more the Great Western Railway spread its tentacles, the more the break of gauge became irritating at different points, so that by 1861 it appeared hopeless to contend against fate, or attempt to carry the wider gauge any further, amid surrounding competitors. At this date, when Mr. Brunel's scheme had been carried to what were to be its utmost limits, the map shows, besides the main line from London to Cornwall, broad gauge routes as far north as Wolverhampton, and west over the whole South Wales district; together with a large extent of territory between Reading, Devizes, and Weymouth, with sundry offshoots.

Then followed the inevitable retrogression, and at the present time, out of seventy-eight regular passenger trains working daily out of London on the Great Western main lines, only seven are broad gauge. By this time next year the broad gauge will be extinct.[1] This is indeed a great pity, as the superintendent of the locomotive office at Bristol recently remarked to me; and if the Board at Paddington could see their way to content themselves with adding a third rail (*i. e.* making a mixed gauge) west of Exeter, the grumbling at the break of gauge at Bristol, to the north, would be removed, while a large bulk of the travelling public, at least in the westernmost counties, would rejoice and give thanks.

This, it may be suggested, is nothing but mere sentiment, seeing that narrow gauge trains are quite as fast, and so long as they do not leave the metals, quite as safe. Granted. But surely some sentiment may be excused under the circumstances, since it was the broad gauge which first taught the world what an

[1] See Note, p. 171.

express meant, and what the achievements of railway engines might be. While trains on older lines were pottering along from station to station, it was the Great Western which "showed the way" to long-distance steaming without stops; the journey from London to Exeter, for example, being run in four and a half hours within a year of the opening of the line to the ever-faithful city. Besides, is the comfort of passengers to count for nothing? "We may reduce oscillation; we may effect improvements in the construction and appliances of the railway carriage; but the disappearance of the broad gauge will be a defeat of the ideal, and we can never hope to make up for the loss of two feet and a quarter in width of base to the passengers, and it is no use endeavouring to persuade ourselves that we can." These are true enough words. With the "Dutchman" or "Zulu" between Bristol and Exeter,—such is the steadiness of the wide gauge,—time can comfortably be made up without this being perceived, except by the rapidity with which the telegraph posts pass the windows; but by the alternative route, when the "Alexandra" is late into Templecombe, the traveller is soon apprised of the fact by the jolts and jerks and undignified scuttle into which the train breaks, and which must be kept up all the way, without a lull, if the driver is to land him punctually in Queen Street Station.

It was remarked by a recent writer, that "no engines in the world have so long and so famous a history as the old engines of Sir Daniel Gooch." This is high praise, but not overdrawn. It is indeed a surprising thing that a type decided upon so early as 1846 should be found capable of performing the duties of express engine in 1891, when the weight of the trains is at least double that which they were designed to draw. If with no material alteration in their structure they are still capable of the results we see, the question naturally arises, what would prevent new broad gauge engines—with ten feet driving wheels, larger cylinders and ports, and with boilers in proportion working up to say one hundred and eighty pounds—from covering the distance between London and Newton (only a few miles from Torquay) comfortably in three hours?[1] True, Mr. Harrison once built an engine, the "Hurricane" (nicknamed "Grasshopper"), with ten-feet drivers, which was a failure; but then that was a monstrosity, with the boiler on a separate frame.[2]

The father of these express engines was the "North Star," a six-wheeled engine, built in 1837 at Newcastle, by Messrs. R. Stephenson & Co., from a working drawing bearing the signature of Mr. Daniel Gooch. Then followed, after an interval filled by various types[3] of coupled and single engines, the "Great Western,"—Mr. Gooch's response to produce a better engine than

[1] The *Times*, April 5, 1893, reviewing *Modern Mechanics*, quotes Messrs. Forney and Eley as saying, in reference to American railroads—"The locomotive of the future is to run 100 miles an hour. Its boiler and fire-box will be much larger than anything now known, the road-beds must be improved in many ways, the curvatures must be few and small, the rails must be heavier, there must be no level crossings, and—the spirit of Brunel will rejoice to hear it—there must be the *broad* gauge."

[2] What purports to be an authentic illustration of this engine is given in *The Mechanic*, February 3, 1893.

[3] An illustration of a characteristic example of these engines (*i. e.* one of the "Leopard" class) is given in *Sir D. Gooch's Diaries.*

the other railways possessed. This was at first a six-wheeled engine, but was quickly given an extra pair of leading wheels, with eight-feet single drivers, built at Swindon in 1846, of the same model as those now at work, except for possessing a large dome and no cab; while the "Lord of the Isles," which attracted considerable notice in the Exhibition of 1851, and was exhibited again at Edinburgh last year,[1] gave an admirable account of its merits by running close upon eight hundred thousand miles before resting from its labours in 1881. The very names of these engines, Tornado, Lightning, Timour, Amazon, Swallow, Dragon, indicate the great or swift things of nature, and to see that expense has not been spared to make them appear worthy of the names they bear, one has only to look at their polished brass domes, splashers, and name letters; their bright dark-green boilers picked out with bands of black and gold; their warm Venetian red wheels and framings, and their bright steel name-plates and axle-covers. When the eye, after dwelling upon narrow gauge models, catches sight of one of them (say, at St. Davids, Exeter), admiration can scarcely be withheld. There is a fineness of physique, comeliness of appearance, brilliance of colouring, and general look of good breeding about the noble creature, which compels attention. It stands out from among the inferior fry with an air of grandeur and symmetry, just as, among the waiting passengers on the platform, some fair and stately Cornish girl, with the Atlantic breezes in her cheeks, and the hardiness of her native granite in her build, may tower above the bystanders, and dwarf her immediate neighbours. Yet for

[1] See Note, p. 171.

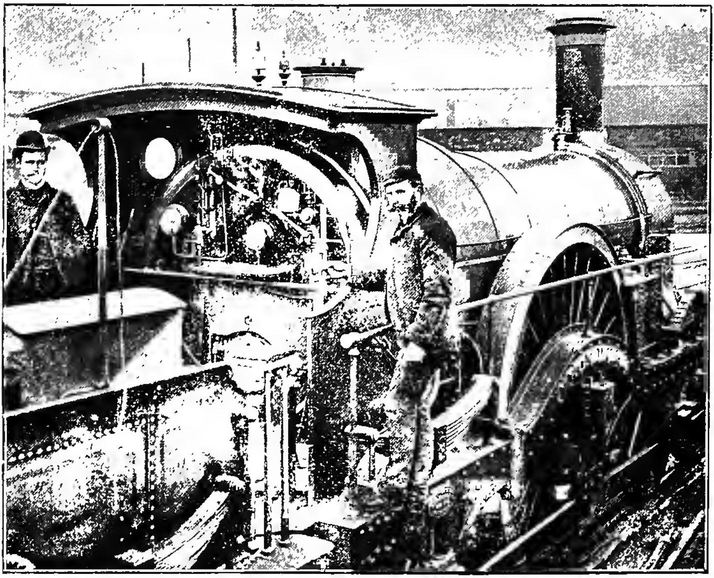
some years past the scrutiny of these great engines has been associated with regret, since, like the larger birds of prey, like the Sioux chiefs hemmed in upon their Western reservations, they are doomed to vanish, and future generations will probably never see the like. Carping critics have affected to observe elements of weakness in the rise of the framing to clear the centre of the driving wheel, and at the break in the boiler at the fire-box. To them it is a sufficient answer to point to the length of time many of these engines have been running, without any such weakness having ever made itself apparent. The secret of that steadiness of motion for which the broad gauge "eight feet singles" have so long been famous, lies in the *width of base*, in the *framing*, and in the *length*. The gentle curves on the main line down to Newton permit the great rail-base of nineteen feet (*i. e.* the distance between the points where the tyres of leading and trailing wheels touch the rail), without the necessity of employing bogie wheels; while the double sandwich frame, composed of two skins of iron with wood between, and the indiarubber cushions in connection with the several laminated springs, conduce to an elasticity of movement which has never been approached by any other class. Years ago the Directors were able to report that the "expense of locomotive repairs, especially on that heavy class of repairs which arises from lateral strains on the wheels and framing of the engines, has been materially less than on other lines," and further experience has probably in no way given them any reason to alter the statement then expressed. These remarks do not of course apply to the saddle-tank engines with low coupled wheels, nor to the Bristol and Exeter single-wheel engines, as reduced to eight-feet drivers, and a bogie at the leading end. The latter had bogie wheels in front, and single frames, and while not running so smoothly, required more repairs than the "Lord of the Isles" class; while the former, though good for steep banks and sharp curves, are certainly not beautiful.[1]

A TRIP ON A BROAD GAUGE EXPRESS LOCOMOTIVE.

Having photographed broad gauge engines at odd times, in every possible attitude, and having seen how they looked from the line, the wish was natural to see how the line looked from the engines, and to gain some practical acquaintance with the routine of engine-driving. Accordingly, permission being very kindly granted from Swindon, I boarded the "Iron Duke" one morning last autumn, in Newton yard, as it awaited the up Dutchman's arrival from Plymouth. When we hooked on, there happened to be another engine behind us, and so there was no need for the display of much enginemanship on the journey to Bristol. The first problem that

[1] The Bristol and Exeter Railway appears to have been engined by the G. W. R. until, in 1856, Mr. Pearson put his first nine-foot single double-bogied ten-wheeled tank engine on the line. These engines, as many will recollect, were among the swiftest of all, and ran the Dutchman brilliantly, until the load gradually became too heavy for them. The driving wheels had no flanges, but this in no way impaired their efficiency: see Board of Trade Report of Bourton accident, 1876, where an outline drawing is given. Their inside frames necessitated the drivers climbing over the top of the splasher; a most perilous undertaking, if they ever attempted it, on a rough night.

presented itself was where it would be advisable to take up one's position, with the likelihood of being least in the men's way : and a seat on the front of the tender seemed about as good a place as any. But as we bowled along by the estuary of Teign, with Shaldon nestling away



THE "IRON DUKE."

under the Ness on the right, and the pretty ivied Tower of Bishopsteignton peeping out of its trees on the left, the discovery was quickly made that such a position was a particularly unpleasant one. Hold as one might, by the tender-rail and tender-seat, and with feet wide apart, the oscillation between engine and tender was so great that the first stop at Teignmouth was thankfully welcomed as an opportunity of abandoning once for all any notion of sitting down. The driver suggested gripping the head end of the regulator with one hand, and the cab-edge with the other; and the remainder of the trip was comfortably performed in that attitude. In this position there was the advantage of an uninterrupted view through the right-hand glass—the driver standing close behind, and watching the signals through such portion of the glass as was not obscured by the cap and head of his visitor. The men, in fact, are bound to *stand* during the whole of their run on quick trains, because they could not sit down much without being shaken to pieces; and if they did sit down, the signals would be invisible unless they looked out over the cab, which would be unbearable for any length of time. But, as might be conjectured, such protracted standing makes them subject to various complaints of the leg, whereby they are not infrequently placed temporarily on the sick list.

It was in passing the oaken glades of Powderham when it became apparent that the footplate of an express is by no means so good a place from which to study the scenery as might be supposed. A novice has enough to do to keep his balance, when holding tight with both hands far apart; he cannot venture to let go one hand and turn round his body, or he would be infallibly precipitated head-first among the coal; the vibration is far too severe to permit of his facing backwards; to keep leaning over the shelter of the cab would make his eyes run, to say nothing of smuts and grit: and the view inside the cab, through the glass, is very much circumscribed, like that of a horse with his blinkers on: on all which accounts, save for a pretty peep here and there, he does not see half so much of the view on either side as from a carriage window.

Such being the case, the scenery had to be given up, and the attention concentrated upon the signals, the work of the shovel, the index of the pressure-gauge, the manipulation of the regulator and lever, and the system of firing. And there was so much to interest in these ways, and the endeavour to see everything all at once proved so absorbing, that the run came to an end far too soon. The signals soon became a fascinating study. Everything—our very lives—depended upon their being seen, and their being right; it was surprising how far off one was able to detect them; and, caring only for those on the left side of the posts, to tell at a glance whether the arm was up or down; it was wonderful too how close one distant signal seemed to the next as we flew along after passing Exeter at a mile a minute. "Enginemen are at all times to exercise the greatest watchfulness; they are to be ever on the alert, and while on duty, to keep their minds entirely fixed on that which is required to be done." This instruction was carried out to the very letter; never for an instant, from Newton to Bristol, were the eyes of the driver (and those of fireman also, except when firing or working the injector) otherwise occupied than in keenly and penetratingly scanning the road ahead; while the same was the case on the journey back. Their ears also were constantly on the alert, to catch the beat of the engine which indicates that all is right with the "motion"; though how they could tell, amid the multitude of noises, was altogether beyond my comprehension.

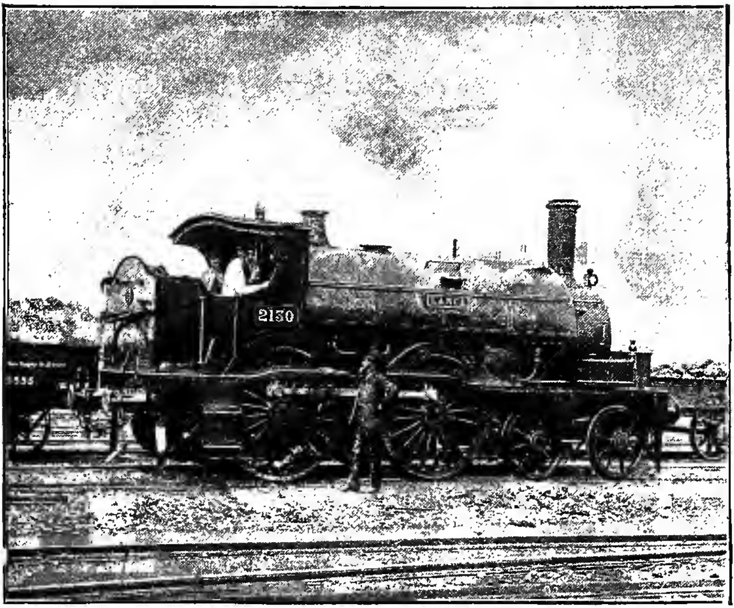
"How do you know that the engine behind us has been doing its fair share of work?"

"By the beat."

Hele and Silverton flashed by, and Collumpton quickly came in view. Here the whistle was sounded long and loud, to warn some rash person on the platform to retire before being demolished. Then a whiz, rattle and bang through Tiverton Junction, and so on towards Burlescombe and the Whiteball Tunnel. With two engines there was no difficulty in mounting the bank; in fact the lever was pretty well in the seventh notch (one next the centre of the sector plate) all through the run.

There is this distinct advantage in being on the engine in going through this tunnel, that the other end shows a small speck of light from the first, and therefore one can be sure the line is clear. The broken lumps of rock in the top make it look like a great black cave; the roar, shaking, and bumping are of course echoed and intensified. There comes to mind the remark of one of the witnesses in the House of Commons when the Box Tunnel was contemplated:—"The noise of two trains passing in a tunnel would shake the nerves of this assembly. I do not know such a noise! No passenger would be induced to go twice!" But had the witness ever been through a tunnel on an engine, he would have modified his opinion about the other train, as his own locomotive would effectually drown any noises but those made by itself.

As a matter of fact, being in almost total darkness, going through a tunnel was not half such a risky sensation as dashing past platforms, or through a network of points. This trip served indeed to correct



SOUTH DEVON SADDLE-TANK ENGINE, "LANCE."

several wrong impressions. Some one has written somewhere, that in going round curves the feeling is frightful, as though the engine were actually off the line. But nothing of the sort was experienced; the engine then, on the contrary, seemed unusually steady; in consequence, no doubt, of the flanges all pressing against that rail which bore the centrifugal force ; and, moreover, the lines are hidden for some distance ahead, on account of the length of the boiler. A long stretch of straight line was infinitely worse ; for a bad length of rail here and there would cause the wheels to bang against the metals, first on one side then the other, with a series of jerks, and deafening crashes, like the united blows of many hammers breaking up iron plates in a foundry yard.[1] It seemed, on these occasions, as if the tyres of the wheels, especially the big driving wheels, were *bound* to snap, or the spokes to break off at the axles. Let the metal be of the very best, it is well known that constant vibration quite alters its character, rendering it crystalline instead of fibrous, and surely such tremendous strains must influence its nature, if anything in the world can. The sensation at these times was indescribable—" terrific " being the only word suggesting itself. If this be " steadiness of motion," one thinks, is it possible for any one to conceive the state of unstable equilibrium in which a narrow gauge engine must find itself under the circumstances ? What may be the length of life of the driving wheels is unknown, but at least their tyres need re-grinding about every fifteen months.

The tunnel past, we began to rush down the Wellington bank, which, as every one knows, is the fastest bit of line between Exeter and Bristol. And here it became necessary to hold on in grim earnest. The regulator was not touched, nor the lever either. " Enginemen

[1] It is right to add, that when any of the drivers report a bad piece of line, the plate-layers are at once set to work to rectify matters.

must on no account attempt to make up lost time in going down incline places." Whether they must or not, "You are going seventy miles an hour," shouted the driver, as we sped our way past the cutting and into the open; through the pretty station of Wellington, and the Victory Crossing, and Norton, until Taunton, with its many churches, appeared ahead, and the steam was shut off, vacuum brake intermittently set to work, and we pulled up at the water-tank, to replenish the tender. It was exceedingly grateful to have a moment's pause, and the chance of standing quietly, arms at rest, and ears released from the strife of noises; and to observe some of the passengers, as people will, looking with admiring eyes at the old "Iron Duke."

Up to this point the shovel had been constantly worked (about three shovelfuls at a time), and the needle had stood steady at 120—*i.e.* just blowing off; the fire had been well up to the bottom of the fire door, and the door had been kept closed.

"When do you begin to let your fire go down?"

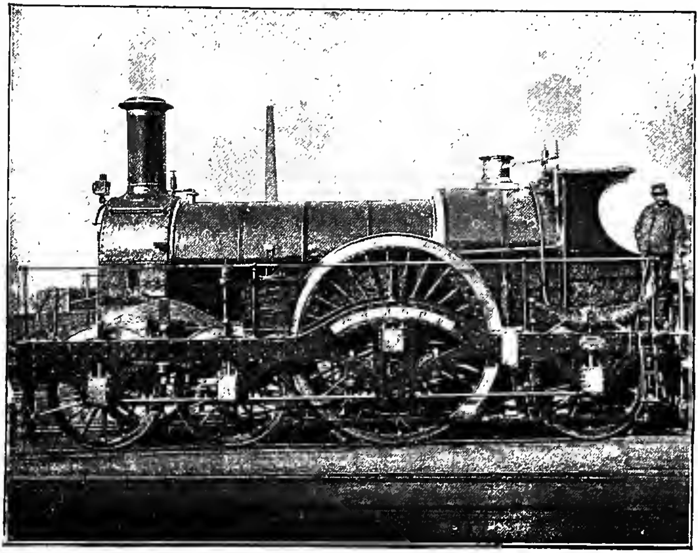
"Not till after Highbridge."

Besides the pressure gauge, an eye was kept on the glass tube. The injector was constantly being opened, and it was a strange thing to see how quickly the water was consumed, and how great shovelfuls of coal vanished. The water in the tube would keep fairly still for a time, so that the shrinkage could be observed, and then would rise and fall with the oscillation; but the practised eye of the fireman could judge of the mean between the jumps of the water, and so know how many inches he had above the lead plug.

Having at length gained one's "sea-legs," the speed could now be thoroughly enjoyed. Looking through the glass, the "Iron Duke" seemed to be bobbing up and down like a horse's fore-quarters, when trotting, as seen from the box-seat; while a glance behind showed the other engine following our movements, like a boat towing astern in a lively sea. One curious optical illusion repeatedly occurred. In approaching and passing under the bridges, it looked as if the chimney were going to be knocked clean off by the arch—so much so that the appearance was ridiculously realistic.

As to the system of firing, it was certainly not that recommended in a certain text-book, where it is stated —"That the fire should maintain steam under all circumstances, . . . it requires to be made in the beginning, and maintained to a form almost resembling the inside of a tea-saucer—shallow and concave, where the thinnest part is in the centre." Both drivers said they liked the fire high in the middle, as the engines steamed better that way; the fireman certainly placed his coal in definite places, near the door, and on either side, according to his discretion, but at no time did the fire appear hollow or concave. It was astounding to notice how soon, after firing, all appearance of smoke ceased. The coal would be shovelled in, where one could see it, and the door closed; and then when the door was opened, two or three minutes later, the black, wet lumps had become melted, welded, and disintegrated, into one even mass of white-hot flame, without a suspicion of carbon or smoke. At every firing, the needle would at once respond and begin to rise; but when the door was opened next time, the fire was the same as if no fuel had but just now been put on: the engine seems literally to devour water and coal.

All too soon we passed Durston, Bridgwater, and Highbridge, with miles and miles of straight line, the



"TIMOUR." ("LORD OF THE ISLES" CLASS.)

Burnham lighthouse close on the left, and Brent Knoll away on the right. Here the driver repeated the tale of some old inhabitant remembering there being nothing but sea where the line now is, and that the nearest land was up the Knoll, where a battle was once fought! This information, conveyed amid a deafening tumult, had to be accepted unconditionally, but probably the old inhabitant meant marshy ground, covered at spring tides. Then Bleadon, with the Steep Holm (and Flat Holm ?) showing up across the level tract ; and we pass under Mr. Brunel's great flying bridge, which seems to grow out of the top of the wide cutting, having no perpendicular work at all ; and one begins to notice that the firing is less frequent, and the fire getting low down. And presently, or a few seconds after as it seemed, there appeared suddenly a charming peep of the Clifton Bridge ; and then, before one knew it, we entered Bristol ; the needle standing at eighty, the fire glowing brilliantly, but well burnt down. Here the engines came off, and a London engine took their place. We had to wait some time outside the station, as all engines have to back by the main down line, and local trains are constantly occupying the platform.

"I wonder you don't get a block with all the engines that come off having to back out by one line," I remarked to the driver.

"So we do, sir, sometimes ; we are nearly always delayed at this Box," he replied.[1]

When we at last got notice to back down into the yard, the "Duke" was stopped at the coal-siding for the men to be photographed, as a future reminder, to their companion, of a pleasant run in their company.

Another wrong impression had been relegated to the limbo of departed mistakes, and this was, that it would be cold and draughty. Far from it, it was quite comfortable, and decidedly warm ; rather too much so when

[1] Since this was written, additional shunting space has been provided.

the fire door was opened. Legs and body were always over warm, and even if the wind had been blowing a gale right into the cab, probably it would not have made itself unpleasantly felt when running fast. Wet feet were certainly possible from the constant play of the hose on the coal, but there was scarcely any grit or dust as compensation.

The two hours of waiting were spent in having a look in at the engineman's cabin, inspecting the Running Sheds, and having a chat with an engineman standing pilot—"A horrid job, doing nothing all day; have to keep steam up, and then at five p.m., perhaps be told I have to go to London and sleep there." On being asked how it happens that the drivers so frequently change their engines, even though the former ones they used to drive may be still at work, he explained it thus: —"An engine, after running so many thousand miles, goes to Swindon to be over-hauled; and when it comes back, if it be a favourite, it is assigned to the most deserving man." Every one in the link is looking out for the best engines, and in this way changes often take place, not without a certain amount of jealousy, or at least of wholesome rivalry.

The down "Dutchman" was timed to leave Bristol at 2.2 p.m., but came in a few minutes late. The "Rover," bright and clean as a new pin, backed down to the platform, and Sanson, the driver, looked along the platform, counted the carriages and chafed at delay.

"Heavy load?" I remarked.

"Seven eight-wheeled coaches, sir, each weighing twenty-one tons; third-class compartments choke-full.

This train used to have no third-class, fewer carriages, and was allowed the same time."

"Shall you save any coal to-day?"

"No coal to be saved by this train," he replied.

And so it appeared. From start to finish the fire-door was perpetually opened, and dripping coal shovelled in. Cook, the fireman, did his work well, never missed shooting the coal (chiefly placed in the centre of the fire) without dropping any of it outside; and when a speck of dust got on the footplate, promptly sweeping it up with his brush. He was a model fireman, always at work, and silent, and never in the way; which is a good deal more than he might have said of his passenger. Of course though coal may be placed in the centre it is obvious that the jolting of the engine will soon shake the several lumps into any hollow in the fire where there may be a lodging place for them, so that the molten mass quickly appears as a level homogeneous layer. We started with the needle at 140, and ended at Teignmouth with the same pressure, as the "Rover" was to work its way back, with a stopping train, shortly after reaching Newton.

The injector, a more modern one than that of the "Iron Duke," was immediately below the pin of the regulator; it was kept gently "on" the whole way, replenishing the boiler by the amount of exhaustion, and keeping the water in the glass tubes wonderfully steady.

It was a fine, sunny afternoon. The ground rises the first six miles to Bourton, and this has to be done in nine minutes, to keep time. The regulator was full open, and the lever in four-and-a-half notch to the top of the bank. Posted at the left-hand glass, it was the fireman's turn this time to have his observations interfered with. The most dangerous part seemed, as before crashing past the platforms; there was just time

UP "JUBILEE," 1.40 P.M., GOING THROUGH EXMINSTER. ENGINE "SEBASTOPOL," MAY 5, 1891.

in many cases, but not in all, to spell out the names of the stations; one's whole attention was concentrated once more on the signals. And here an unforeseen difficulty presented itself. The sun was getting low (3 p.m., November) and shone full in our faces right up to sunset; the farther we proceeded the worse the dazzle; it was utterly impossible for one unused to the work to see whether many of the signals were on or off, right in the glare and against the sun, and this must be a great strain on the men's eyes. When questioned about it, the driver confessed that it was "bad enough," but remarked that after all it was not half so trying as snowstorms, when the snow would darken the glass, so that scarcely anything at all could be seen.

At Taunton the tug of war was to begin, it being a steep pull from here right up to the Whiteball.

"You generally take a bank engine here, don't you?" I observed to Sanson.

"Yes, generally, but I shall try and get through to-day," he answered.

This was good news indeed, seeing that an engine in front would smother us with its smoke, and prevent one seeing how the "Rover" would mount the long bank single-handed. On this point Sanson was evidently of the same opinion as one of his former comrades, an ex-driver of the "Lightning," who writes thus:—"You must start at Taunton if you are going to get up the bank in time, and not put the lever back in the seventh notch, but after getting away let it stop in the sixth, until after passing Wellington; then give it another notch or two, and not wait until the speed has got too slow. With a big wheel you must keep them going, if you don't, and your engine should start slipping, you would be very soon brought to a stand. I have had many a hard struggle up the banks with heavy trains, though I always got through with them both up through

Box Tunnel and Wellington Bank; but I always started *at the bottom* for them."

After Norton, the pace soon began to be less violent, and the panting of the engine showed that the resistance on the pistons was increasing. As Wellington was neared (where the monument stands up against the sun, making a pretty view, in the haze), another notch was given the lever, and still another. Then began an anxious time. Having read in a certain work that "to climb a long bank, instead of the engine blowing off, it should rather be inclined to be short of steam, so that the steam can be allowed to push the pistons nearly to the end of the stroke, following it up with an even pressure," I thought that with a boiler full of steam, as ours was, some steps would be taken to partially close the regulator, or notch up the lever. But here, again, doctors obviously differ. The regulator was wide open, the lever in the second or third notch, and the intention evidently was to mount the bank as quickly as possible by the sheer force of high-pressure steam.

The driver and fireman "stood by" eagerly listening, and at the least suspicion of slipping, worked the sand-gear quickly. A little rain was falling, the rails were moist, and the sand-lever had to be worked more than once.

"Then you don't put down the damper, or check your steam in any way, up the bank?" I remarked.

"No, let her have it: the 'Iron Duke' stuck in the tunnel last week," answered Sanson. Pleasant experience.

I noticed as we laboured on how the firemen kept tending his fire with extreme care, selecting nothing but clean lumps without any small stuff, and constantly feeding the furnace, keeping the needle well up to 140. There must be a tremendous blast in the furnace when the lever is well over. A great lump of coal does not get dull red first round the edges, as in a grate, but disintegrates uniformly and at once; fiery smoke comes from between the strata of the block; it seems all in a simmer, and grows white-hot almost in a moment.

And now the pace is at last really slow as the "Rover" pants its very heart out; but then here we are entering the tunnel, and our troubles are over. The lever is put back in the seventh notch, and away we start for Tiverton, Collumpton, and Silverton—here the speed is always great on down trains—and so on, in the waning light, through Stoke Canon, right into St. David's, without a single check from Bristol, and only one adverse distant signal, which, being observed far ahead, was "blown down" by the whistle without altering the speed.

Many trains had been passed, some broad, some narrow gauge; these did not look at all as if they would run into us, as one saw a long way off that the coming train was on its own line; and in every case the din and turmoil of our own engine entirely drowned all noise from the other; even as an express rushed past, no increase of sound whatever was perceived: it might have been a phantom train, or standing still.

At Exeter we went down under the engine, but there was no need to oil anything, as the "Rover" proved to be in tip-top trim; cranks of driving wheels quite cool, bands of eccentrics just luke-warm. Between St. Thomas's and Exminster attention was drawn to the "new road," which was pronounced much better than the old, being "more springy"; this, like many other things, had to be taken on trust by one who could not

"DUTCHMAN" AT FULL SPEED DOWN GRADIENT, PASSING STOKE CANON STATION, 3.50 P.M., MAY 9, 1891.

detect the slightest difference in the vibration ; anyway one is sorry to see the old longitudinals thus disappearing, which have always proved so safe, when an engine has gone off the rails. We flashed through Starcross at great speed ; a nasty, risky piece of line, where it looked as if the engine would bump against the wall of the Hotel, and *ricochet* on to the pier ; and so on in the gloaming, through the warm red cuttings and tunnels of Dawlish, by the sea-wall of Holcombe, and on into Teignmouth, where the trip ended. And yet scarcely ended, for a brand-new kind of nightmare was evolved from the run, and it soon transpired, from the vivid pictures of one's slumber, that the racket of the footplate could be well rehearsed in dreams.

[Table showing sections of line converted to narrow gauge is given on opposite page.]

NEW NARROW GAUGE GREAT WESTERN ENGINES.

By A. H. MALAN.

THE chapter on Broad Gauge Engines was scarcely complete without some reference being made to those locomotives destined to take their place ; but it was not desirable, at that date, to speak of such examples of the new design as were then at work, because these were running on temporary broad gauge wheels, and consequently might be looked upon as being in an imperfect state until reduced to their permanent proportions.

Thirty narrow gauge engines have been built at Swindon, to run between London and Newton, and take up the work of those illustrious veterans which are now but a cherished historic recollection. With the symmetry of the eight-feet singles still fresh in the mind, it is highly improbable that any one would be greatly biassed in favour of their successors, on the score of

GREAT WESTERN RAILWAY.

SECTIONS OF LINE CONVERTED TO NARROW GAUGE.

Date of conversion.	Section of Line.	No. of Miles.	Remarks.
1868	Princes-Risborough to Aylesbury	7	
1869	Oxford to Wolverhampton, with Stratford and Great Bridge Branches	$89\frac{3}{4}$	
,,	Grange Court (near Gloucester) to Hereford	$22\frac{1}{2}$	
,,	Reading to Basingstoke	16	
1870	Maidenhead to Oxford	37	
1871	West Drayton to Uxbridge	$2\frac{1}{2}$	
,,	Whitland to Carmarthen	$13\frac{3}{4}$	One line only.
1872	Swindon to Milford and all Branches	$239\frac{1}{2}$	
,,	Vale of Neath, Merthyr Branch and Cheltenham to Grange Court	$60\frac{1}{2}$	
,,	Radley to Abingdon	2	
,,	Didcot to Oxford	$10\frac{1}{4}$	
1873	Bristol and South Wales Union	12	
1874	Thingley Junction to Dorchester; Westbury to Salisbury; Bathampton to Bradford Junction; North Somerset Junction (near Bristol) to Frome; Reading to Holt Junction, with Marlborough and other Branches	$197\frac{1}{4}$	
,,	Dorchester to Weymouth.........	$6\frac{1}{2}$	
,,	Southcote Junction to Reading	$1\frac{3}{4}$	
1875	Southall to Brentford..............	4	
1876	Twyford to Henley-on-Thames	$4\frac{1}{2}$	
1878	Uffington to Farringdon	$3\frac{1}{2}$	
1880	Yatton to Clevedon	$3\frac{1}{2}$	
,,	Durston to Yeovil (Pen Mill) ...	$20\frac{1}{4}$	
1881	Norton Fitzwarren to Barnstaple	$42\frac{3}{4}$	
1882	Norton Fitzwarren to Minehead	$22\frac{3}{4}$	
1884	Tiverton Junction to Tiverton...	$4\frac{3}{4}$	
1891	Creech Junction to Chard.........	12	

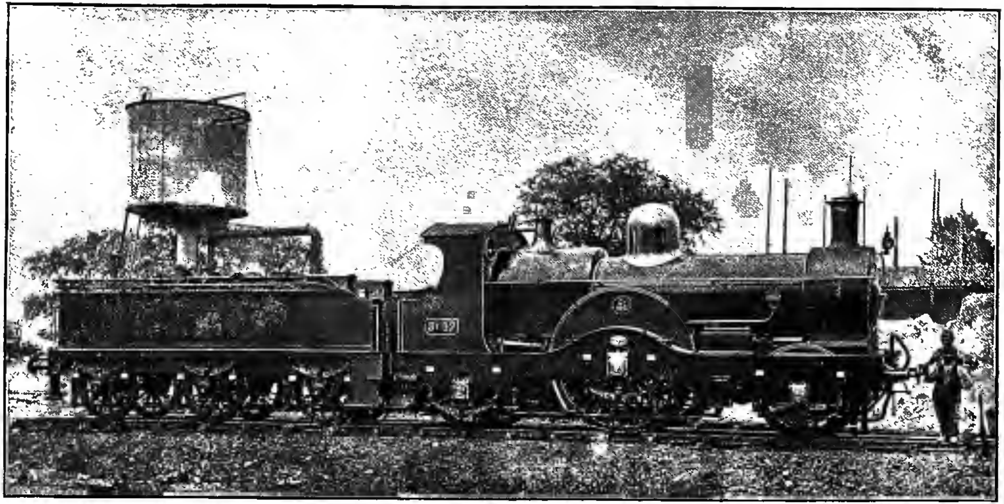
The length of line between London and Penzance is 326 miles 24 chains, and between Mutley and Launceston 34 miles 25 chains. Of the former 100 miles and of the latter 12 miles 34 chains are exclusively broad gauge, external beauty, save in so far as beauty may be said to lie in the adaptation of *any* piece of workmanship to the object for which it is fashioned. And yet they are veritable "greyhounds of the rail," even though their outward form *does* partake rather of the bull-dog type than of the make of the more slender quadruped; for there is no question that the new creations of Mr. Dean are exceedingly swift, powerful locomotives. This they have every reason to be, with pistons 20 inches in diameter, 24 inches in stroke, actuating driving wheels 7 feet 8 inches, by virtue of a boiler pressure of 160 lbs.

Two features in their outline can hardly fail even at a distance to strike an observer:—

(1) The high dome.

(2) The raised fire-box.

(1) The history of domes on this railway is somewhat curious. The early engines had no domes upon their boilers, but some of them had, instead, upon their fire-boxes, protuberances like great round dish-covers. Sir Daniel Gooch (then Mr.) subsequently to his "North Star" type (1837) adopted round-topped, square-bodied fire-boxes in those engines constructed between the years 1839 and 1846, of which the first of the "Great Westerns" may be cited as an example; but he abolished them once for all in his "Great Britain" type, and his example seems to have been copied on the Bristol and Exeter Railway, the first of the nine feet singles, built in 1856, having neither elevated fire-box nor dome. In 1867 he was succeeded by Mr. Armstrong, who was an advocate of a dome upon the boiler; and from that time until the present, narrow gauge engines adorned with brass



NEW NARROW-GAUGE ENGINE, NO. 3017.

cupolas have been more or less prevalent. Some of the single engines, constructed previously to the new series, and known as the Sir Alexander class, have been domeless, while other members of the same family have had domes added afterwards; but it has remained for the more recent subjects of this article to give the highest expression to this method of securing dry steam—the excrescences thereupon reaching, as is seen, to the level of the squat chimney top.

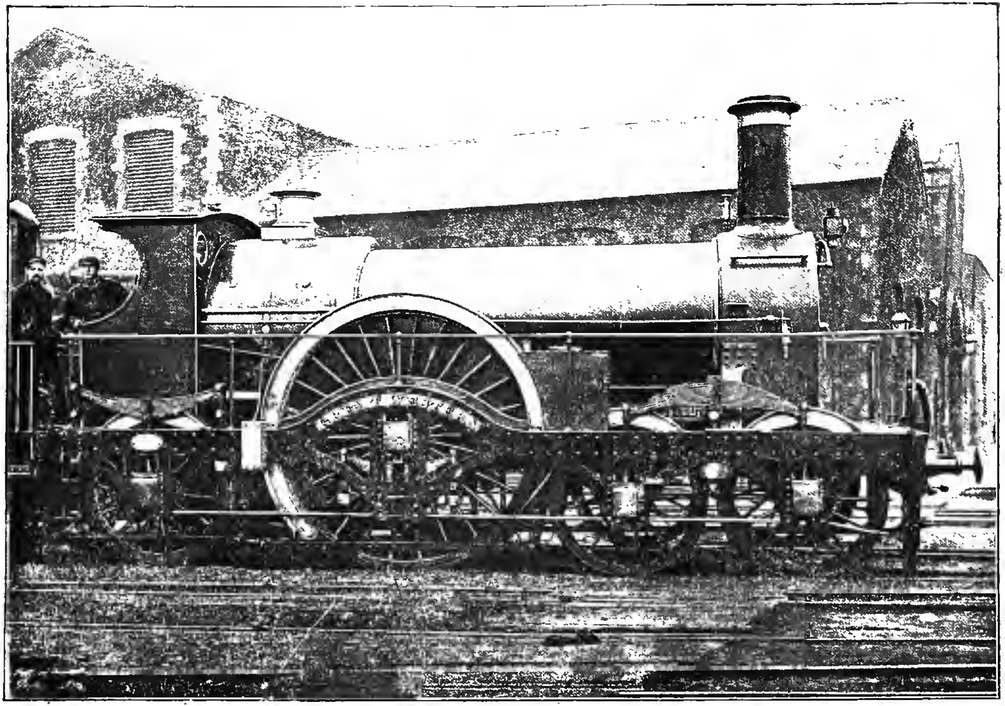
(2) In the raised fire-box there is another survival from the past, re-introduced after partial abandonment in the *narrow* gauge Great Western engines, and almost total abandonment elsewhere. It is strange to notice *this* feature preserved in a brand-new type; but its perpetuation certainly tends towards discounting that attribute of weakness which was conjectured to be incidental to any break at the heating end of the boiler. These raised fire-boxes, however, are rather different from those on the broad gauge, in that, while being raised to a certain height at the top, they become gradually flattened at the sides, in order to allow the driving wheel to pass.

Coming to closer quarters, and especially taking a view from between the front buffers, it is seen that these new specimens of Great Western workmanship are remarkably high-pitched, and presumably top-heavy; the top of the smoke-box being at the same elevation from the rail as in the "Lord of the Isles," class, with all the difference of a seven feet and a four feet eight and a half inches base.

A high centre of gravity is strictly in accordance with modern axioms on locomotive construction, among which is the assertion that a high-pitched engine runs more steadily than a low-pitched one. This theory may be correct within certain limits; and it may also be the case that the wear and tear of the line is lessened if the boiler is well elevated. Yet it is allowable to suggest that, after all, the element of making a virtue of necessity may be far from absent in regard to this matter. For, given a large driving wheel—desirable in express work, to secure a reasonably low piston speed—engines now-a-days can hardly be otherwise than high-pitched, unless a portion be scooped out from the under part of the boiler, so as to leave room for the revolution of the cranks in cases where the axles possess cranks. Be this as it may, any one who has repeatedly watched the old broad gauge heroes steaming grandly along, with marvellous steadiness, will not hesitate to affirm that those by which they have been superseded, certainly do *not* emulate their predecessors in smoothness of motion. All things considered, it was never to be expected that they could do so; but the point to observe is, that those now extinct monarchs of the seven-foot way must be classed as *low-pitched,* when the width of base in the two models is taken into consideration.

When in May funeral orations were pronounced upon Mr. Brunel's system, remarks were not wanting in the newspapers to the effect that the broad gauge was an "expensive and needless mistake;" but the plain truth is, *that* gauge was by no means so serious a mistake as to tie down the country to such a narrow gauge as unfortunately enjoys a monopoly on the iron road. The now universal gauge (in England) was not only accidentally, but prematurely settled upon; it has no particular merit whatever to boast of, and its most zealous champions would in heart be glad enough at the present time—with modern loads, modern speeds, and corridor trains looming in the near distance—to have more width for their engines, and more width for their carriages, if that were feasible. The broad gauge, like the *Great Eastern* steamship, was born before its time; but if it had been possible to increase within moderation—to expand transversely the dimensions of railway stock, as it has been possible to increase the dimensions of steam vessels, the English world would probably have seen the same approach towards Mr. Brunel's standard of greatness and efficiency taking place gradually on *land*, as has occurred, and is occurring, at *sea*. The ss. *Campania* is only eighty feet shorter and eight feet narrower than that stupendous failure the *Leviathan*—a failure rather in engine power than in hull;—and who can foretell how soon the full dimensions of Mr. Brunel's marine monster may not yet be reached? [1] A similar elasticity of growth on railways has, of course, been impossible, with a gauge fixed at haphazard, when there was little knowledge of railway economics, and locomotives were yet in their infancy. In this matter Ireland has a practical form of Home Rule to its distinct advantage, the Irish gauge, 5 feet 3 inches, being superior to the so-called "national" gauge of England.

[1] The *Gigantic*, now on the stocks, is to be 700 feet long, and her engines of 45,000 h.p., against the *Leviathan* of Mr. Brunel, 680 feet long, and 7,650 h.p.



THE "GREAT WESTERN," THE ENGINE WHICH DREW THE LAST THROUGH BROAD GAUGE TRAIN FROM PADDINGTON, 20TH MAY, 1892.

Only one objection, carrying weight, has ever been urged against the broad gauge, *per se*, apart from primary cost of construction and maintenance of the permanent way; and this is, that the distance between the wheels gave a tendency to the crank-axles to twist. If the charge *were* well founded, one would think the difficulty could be met by constructing the crank-axles of stouter material; but in reference to this, it would be extremely interesting to have a return furnished with performances of, say 20 n. g. and 20 b. g. express engines per 50,000 miles each, showing how far this objection has been practically felt. Broad gauge engines when running have *broken* their crank-shafts, and narrow gauge engines have not been immaculate in that way; but as to what percentage of broad gauge engines have had to return to Swindon on account of *twisted* axles, or what the percentage of *broken* broad gauge axles has been, compared with broken narrow gauge axles, these are points upon which the archives of Swindon would have to be searched before any judgment could be pronounced. And even if the archives did divulge their secrets, the comparison would be scarcely fair, as it is unlikely that any great expense has been laid out of recent years upon broad gauge engines, their existence having been known to be restricted.

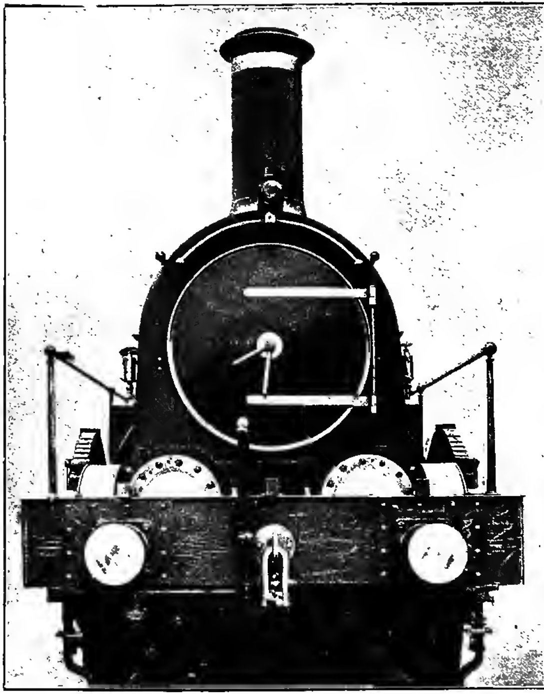
As to the desirability of increased width of base, certainly the drivers of these new engines would gratefully accept such a boon as even an extra foot. The transition from the roominess of their former iron horses, "below decks," to the cramped motion of their present charges was sudden and extreme. When the men first "went below," on oiling intent, they were not more at home than an owl in a canary's cage, and though now philosophically disposed to accept the inevitable, they still hanker after the "Swallow," "Lightning," etc., which they gave up with such genuine regret. As a set-off, however, there is more shelter in the larger cabs with which they are now provided; and the increased comfort on the "quarter-deck" must be looked upon as compensation for the restriction of space elsewhere.

It was a bold step to introduce cylinders of such large calibre as twenty inches in engines that are not coupled, but single-wheeled. It might be anticipated that with pistons of this size, and 160 lbs. of pressure behind them, the driving wheels, in spite of their nineteen tons share of weight, would be disposed to slip at starting; and some individuals have frequently been observed to transgress in this respect when getting under way. This may perhaps be remedied, to some extent, by the general adoption of the sand-blast; it would be well if the awkward bend in the sand-tube could be avoided, this defect having led to the end of one fireman, who met his death, as his engine was running and slipping, when endeavouring to get the (damp) sand to pass through the tube.

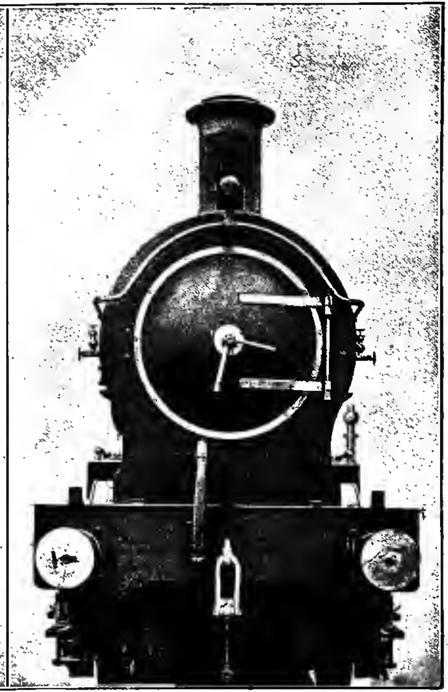
Standing on the foot-plate one sees that the good old-fashioned regulator, the handle of which the driver drew out comfortably towards his body, has departed in favour of the more usual kind, which has to be pushed from him at arm's length. The earlier broad gauge engines had but a single gauge-glass, the re-builds two; here there is but a solitary tube. This reversion to the previous type is due to the theory, that two glasses were better than one, being upset by the fact that when one broke the other promptly followed its bad example, and therefore duplicates were found to be of no real benefit. Again, the old familiar sector-plate with lever has vanished, and a screw reversing-gear has taken its place. This may be a good plan for regulating the motion under ordinary circumstances; but if, at seventy miles an hour, it ever came to a question of moments whether by reversing the engine a collision could be prevented, the hand lever might be found wanting, seeing that the new arrangement is much slower in action. Perhaps the screw might be made to work more quickly by steam; or a duplicate action might be introduced as an alternative, whereby, in an emergency, reversal could be effected instantly, without the intermediate stages, corresponding to the notches of the sector-plate, being laboriously passed through by the hand-screw.

It is early days yet to adjudicate upon the general character of these large and powerful engines. In the winter, when the weather is rougher and the rail wetter, the load will usually be lighter, and hence it is reasonable to assume their performance will not be less satisfactory than in the summer months. As regards speed, nothing remains to be wished for. Whether it is a wise thing with such heavy engines to have but one pair of leading wheels is a point on which opinions might vary.[1] The easy curves between London and Newton do not

[1] Sir D. Gooch's first "Great Western" had originally but six wheels, but he quickly found it necessary to add an additional pair of leading wheels.



FRONT OF THE "GREAT WESTERN."



FRONT OF NEW NARROW GAUGE ENGINE, NO. 3,014.

When photographing, the lens was placed, in each case, 22 feet 8 inches from the buffer plate.

necessitate bogies, and obviously there is less friction and waste of power with six wheels than with eight; but should a leading axle ever snap at a high speed, the result would be so disastrous, that, if only as a safeguard, an additional pair of wheels might perhaps be an advantage. The directors can hardly desire, still less hope to secure, a finer record of endurance and all-round excellence than has already been achieved by the famous engines of Sir Daniel Gooch. Whether the record will show similar economy of repair, economy of coal, and immunity from serious loss of life in accident, is a question for the test of time to decide; but at least it may be hoped, in advance, that the verdict of the future will be so far favourable that the prestige of the Great Western engines will not have materially suffered through a change of gauge, never desired by the authorities for its own sake, but forced upon them as an imperative necessity.

COMPARATIVE MEASUREMENTS OF B. G. SINGLE, AND NEW N. G. SINGLE ENGINES.

	B. G. ENGINE. ("Great Britain.")	N. G. ENGINE. (Class 3000—3030.)
Weight of Engine	41 tons 14 cwt.	44 tons 4 cwt.
,, Tender	30 tons	32 tons
Cylinders—Diameter	18 in.	20 in.
,, Stroke	24 in.	24 in.
,, Steam ports	13 in. × 2 in.	14 in. × 2¼ in.
,, Exhaust	13 in. × 3½ in.	14 in. × 3½ in.
Boiler—Barrel	11 ft.	11 ft. 6 in.
,, Diameter	4 ft. 6 in.	4 ft. 3 in.
,, Outside Fire-box	5 ft. × 6 ft.	6 ft. 4 in. × 4 ft.
,, Inside ,,	4 ft. 3½ in. × 5 ft. 4 in.	5 ft. 8 in. × 3 ft. 4 in. × 5 ft. 11¾ in. high.
Tubes	332	245
,, Diameter	1⅝ in.	1¾ in.
,, Length	11 ft. 5¼ in.	11 ft. 9 in.

	B. G. Engine.	N. G. Engine.
Wheels—Leading and Trailing	4 ft. 6 in.	4 ft. 6 in.
,, Driving	8 ft.	7 ft. 8 in.
	sq. ft	sq. ft.
Heating Surface—Tubes	1598	1321·04
,, ,, Fire-box	153	123·88
Total	1751	1444·92
Area of fire-grate	24 sq. ft.	20·8 sq. ft.
Working pressure	140 lbs.	160 lbs.
Water capacity of tender	3000 gals.	3000 gals.
Rail base of engine	19 ft.	18 ft. 6 in.
Height of smoke-box from rail	10 ft. $3\frac{1}{2}$ in.	10 ft. 3 in.

Postscript. June 1893.—Sufficient time has now elapsed to test the merits of these engines; and it cannot be questioned that there remains much to be desired in the matter of steadiness. The writer spent a day last month near Worle and Yatton—level, clear stretches of line, free from "points,"—for the purpose of observing their actual importance. To the eye the motion appears as a fretful see-saw (with the driving axle as fulcrum), and brings out into striking contrast the plumb-level travel of the broad gauge singles. This see-saw motion, save for being rather trying to the permanent way, would not much signify if there was only moderate steadiness on the foot-plate; but such is very far from being the case, according to the testimony of those best able to judge, but perhaps not equally able to speak for themselves. Probably some alteration will of necessity be in time introduced; but before an intermediate pair of wheels can be given, the turn-tables must be lengthened.

Meanwhile, Mr. Dean (following the example of Sir D. Gooch, with his "coupled *Almas*," or "Rob Roy" class) has built some coupled engines, with 6 ft. 6 in. driving wheels, and $17\frac{1}{2}$ in. cylinders. In these newest of all locomotives it is seen that the raised fire-box has once more vanished; the area of the fire-grate is 15.5 sq. ft., the total heating surface 1367 sq. ft. They appear outwardly very serviceable engines, and there seems every likelihood that they will give a good account of themselves.—A. H. M.

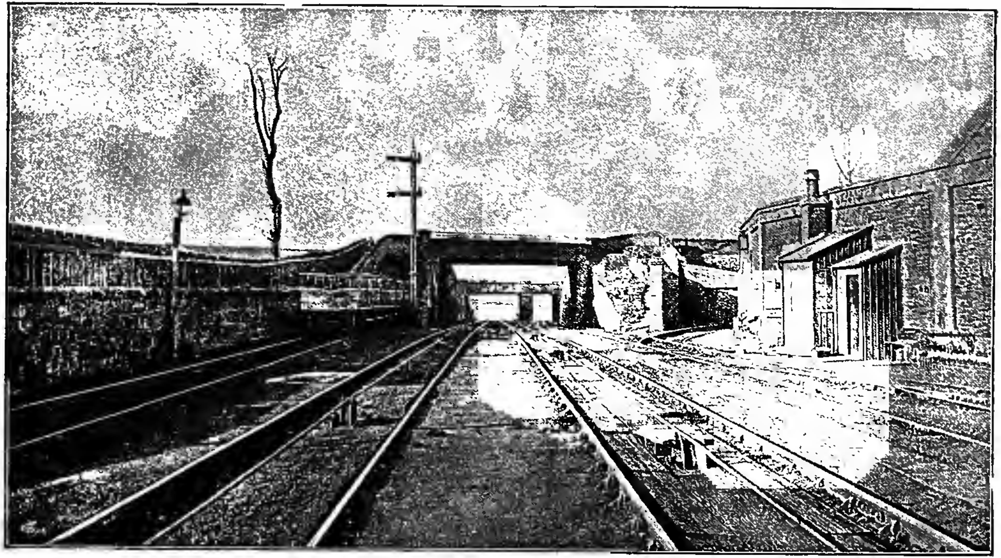
CHAPTER VIII.

THE NORTH BRITISH RAILWAY WORKS AT COWLAIRS.

By A. E. LOCKYER.

On the 18th of February, 1842, railway communication was first established between Glasgow and Edinburgh, and in honour of the event both cities were decorated and great rejoicings took place. The "Edinburgh and Glasgow Railway" had been incorporated by Act of Parliament in 1838, with a capital of £900,000 in shares and £300,000 on loan.

The line, which took about three years to build, and cost fully a million and a quarter, is without doubt one of the finest specimens of engineering skill among the British Railways existing, considering the rocky cuttings and steep banks which had to be dealt with. Its length is $47\frac{1}{4}$ miles, and it enters Glasgow on the north side, having as its terminal station Queen Street. Before arriving at Queen Street, however, one passes through a small suburban station, "Cowlairs." It was here where the great difficulty arose in making the line, for although Cowlairs is only a mile and a half from Queen Street, it stands 150 feet above the level of George's Square. So there was nothing else for it but to make



THE INCLINE AT COWLAIRS.

an incline, and work it either by rope haulage or locomotives. It was first proposed to work the incline with a land engine and rope haulage. When the incline was cut it showed a gradient of 1 in 42, with a length of about a mile and a quarter, the lower half of which passes through a tunnel—the tunnel alone being the biggest piece of work ever performed in Scotland, involving a cost of £40,000. Over the tunnel in one place runs the Forth and Clyde Canal, giving only a few feet clearance between the brickwork of the tunnel and the bottom of the canal, so that great precautions had to be taken in building the brickwork of the roof.

The line was finished and opened for traffic in 1842, the first time-table making its appearance in February; there were only six passenger trains and two goods trains per day, but the traffic steadily increased. The haulage rope at Cowlairs, however, which was at this time made of hemp, did not work well, especially during wet weather. There were not wanting engineers who now came forward and condemned the incline entirely, stating it would require a quarter of a million of money to rectify the blunder which had been perpetrated.

Mr. Paton, who was at that time Locomotive Superintendent of the line, came to the rescue, and stated that for the interest of that sum for one year he would solve the problem. His plan was to do away with the land engine and rope, and substitute locomotive engines, saving all expenses connected with the haulage. The sum was voted by the directors, together with an addition to the salary of the Locomotive Superintendent for his able suggestion; four heavy locomotives were built, named respectively, "Samson," "Hercules," "Millar," and "Hawthorne"—Samson and Hercules being constructed at Cowlairs Works, and Millar and Hawthorne at Newcastle. They had 18 inch cylinders with five feet driving wheels coupled in all the six. To prevent the exhaust from injuring the roof of the tunnel it was lined with sheets of iron.

The land engine was therefore stopped in 1844, and the locomotives were tried. They had not run any length of time, however, before the foreman plate-layer complained of the engines destroying the rails, which, it must be remembered, were only 58 lbs. per yard, with the sleepers three feet apart. In consequence of this report the incline was relaid, altering the sleepers to two feet centres. This did not much mend matters, and, to crown all, the Forth and Clyde Canal began to leak, in consequence, no doubt, of the vibration induced by the constant passage of the heavy locomotives. A strategic movement to the rear then became necessary, and an eminent engineer (Mr. McNaught) was appointed by the directors to strengthen the land engine and put it in proper working order, so as to reintroduce the haulage system for working the incline. A Newcastle firm (R. S. Newall & Co., the original inventors and patentees of untwisted wire rope) supplied the railway company with one of their wire ropes. The land engine was finished by the 4th of March, 1847, and on trial under the new conditions the haulage system proved highly satisfactory, so much so that the four locomotives were removed altogether.

The land engine and incline rope are working to this day, having been there now for over fifty years. The incline engine is a double-cylinder beam engine, the cylinder being 36 inches in diameter, with a stroke of 6 feet, and working at a pressure of 45 to 50 lbs. per square inch; each rope, it may be noted, lasts on an average about twelve to fifteen months, some as long as seventeen months. It is over three miles long, all in one piece, and made endless by splicing the two ends together, the return rope going down the incline in between the "down" rails. The weight of a rope is just about twenty-four tons. At the top of the incline may be seen what is supposed to have been the first signal-box in Scotland, *i. e.* the first building whence the points and signals were worked together, in place of using the old "balls" which one still sees sometimes in shunting yards. The box, which has a clock on the top, is not worked now, but simply kept up as a relic or curiosity. In 1858 the Edinburgh and Glasgow Railway acquired the control of the Glasgow, Dumbarton, and Helensburgh Railway, which runs along the north side of the Clyde. This induced the directors to slightly alter Queen Street to meet the traffic. Since the amalgamation of the Edinburgh and Glasgow with the North British Railway, and the opening of the station on the underground railway at Queen Street, a complete remodelling of Queen Street Station itself has taken place.

The North British Railway as it now stands is divided into four sections. The north of the Forth represents the northern section; south of Edinburgh along the Waverley route to Carlisle the southern; east of Edinburgh to Berwick the eastern; and, finally, the western section going west from Edinburgh to Glasgow. Edinburgh is the centre of the system.

The main line between Glasgow and Edinburgh passes the Campsie Hills, going in almost a straight line to Edinburgh through Polmont Junction and Linlithgow. At Winchburg Junction the line divides, the main line going out of sight to the right, the other crossing the Forth Bridge to Dundee and the North. Prolonging our journey onward we pass through Corstorphine, a junction where the line comes in from the North. In a few minutes more we find ourselves at Haymarket. From here to Waverley Station in Edinburgh is a mile and a half, two-thirds of which is tunnel. It is here (Waverley) that the North-Eastern locomotives couple on to the trains which go to London or anywhere past Berwick, but the line right to Berwick belongs to the North British Railway, the North-Eastern having only running powers.

Just outside of and beyond Edinburgh, at a place called St. Margaret's, are the Locomotive Works of the old North British Railway previous to the amalgamation in 1865. They are still in operation, a great many engines belonging there, but since 1865 Cowlairs has been the central works. Repairs only are done here, the building and thorough overhauling being left entirely to "Cowlairs."

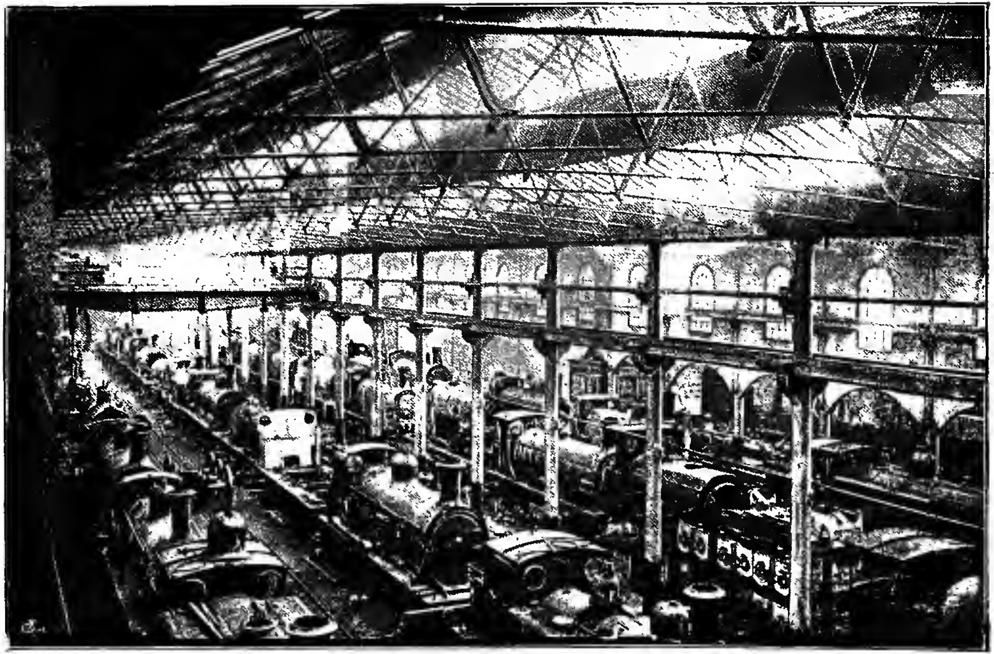
The chief offices of the Company are in the capital of Scotland, and the head-quarters of the Locomotive Department at Cowlairs.

One must bear in mind, of course, that the North British Railway cannot boast of such large figures in the way of mileage and quantity of stock as some of her large southern neighbours. It represents, however, the biggest in Scotland, having a mileage of 1,217 miles. The rolling stock is also of the most modern design both for speed and comfort, the passenger rolling stock being all equipped with the Westinghouse air brake, some also with the vacuum in addition, both brakes acting in unison.

As regards the lighting of trains, the North British Railway has adopted Pintsch's patent for burning gas in the carriages, but they also have trains fitted up with the electric light as well as the gas, the electric light only being used in the daytime. This, however, is confined to those running on the Glasgow Underground Railway. The system here used, so far as I know, differs from that on any other railway. The train, in this case, has not the battery, accumulators, or dynamo on board, but simply the lamps and wires. The wires lead down beneath the coach, being connected to a communicating pulley which hangs underneath the carriage. In the tunnels and places where the train is to be lighted up, a conductor is bolted to the sleepers and carefully insulated, being charged in some cases by the same dynamos which supply the stations with electric light. The train passing over the conductor causes the communicating pulleys beneath the coaches to mount and run along the top of it, thus completing the circuit and conveying the current to the lamps, which give a splendid light. To allow for any irregularities of the road, the communicating pulley works beneath a spring which has about three inches travel, thus ensuring the maintenance of a steady light. Although there is a communicating pulley under each coach, the whole train is connected to the current by means of the wires which terminate and are soldered to the side-chain hooks of the carriages, and which, being coupled together, act as conductors. At night-time, when the gas-lamps in the train are constantly burning, the current in the main conductor is switched off, in which case the train simply runs over the conductor without receiving any current. This mode of electric lighting not only obviates the constant burning of the lamps, thus saving wear and tear, but is also quite automatic in its action—a point highly essential in all railway working. The method of communication between passengers, guard, and engine-driver is decidedly worthy of notice. The "cord system" is adopted, which may be briefly described as follows:—On all fast trains there is a cord running from end to end of the train through the small ring one sees fitted along the combing of the coaches and vehicles for passenger traffic. At the engine end it is attached to a small lever which works the spindle of the whistle. At the rear end of the train it is connected to a drum in the guard's compartment, which on rotating strikes and sets ringing a clockwork bell. If any passenger therefore has occasion to "pull the cord" it both blows the engine whistle and calls the attention of the guard. Some trains have also an electric bell and battery fitted, but as yet this is only in an experimental stage.

We will now direct our attention to Cowlairs, the central works of the Company.

The Erecting Shop has accommodation for sixty



ERECTING SHOP.

engines. On our way round we note one or two of the old patriarchs having frames of a combination of wood and iron. In comparing the modern engine with one of the old school, one is struck with the similarity, the progress made being more of detail than of arrangement. Again, in the matter of speed, some of these old stagers can keep pace with any of the modern ones, as was exemplified in the recent race from London to Edinburgh, when the London and North-Western Railway used an engine twenty-six years old to run a portion of their trip.

A noticeable machine at work here is a cylinder boring mill. As the cylinders of an engine get oval in time they require to be re-bored. The machine is very simply fixed, being carried by two brackets which bolt to the angle irons that support the buffer-beam, the opposite ends of the boring bars being supported by glands fixed to the stuffing boxes. It is driven from a shaft which runs the whole length of the shop, and commands two rows of pits, so that a connection can be established between any engine and the shaft. Both cylinders are bored in the one operation. The feed-gear of the machine is of an ingenious description, being a combination of the pendulum and the sun and planet motion.

In the Wood Department we watch the process of making carriage wheels having wooden centres. They have a cast-iron ribbed centre, which forms the boss; between these ribs the teak blocks which form the wheel are fitted and bound in position, by a washer-plate and bolts, to the part forming the boss. The tyre is then forced upon the wood by hydraulic pressure, and held in place by two retaining rings and bolts. The axle is next forced on, and after being turned up, the whole is balanced. If the wheel should be light on one side, then an iron plate of the necessary weight is bolted on to bring back the balance. This balancing is a very necessary item in smooth running, more especially at high

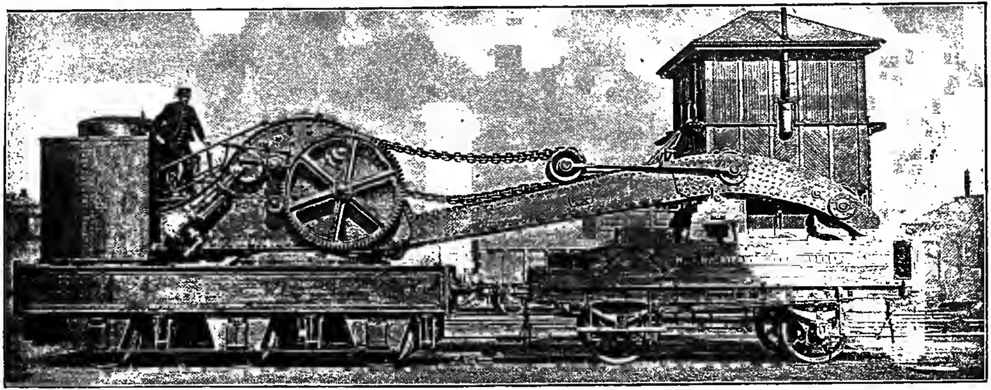
CONSTRUCTING THE WOODEN WHEEL.

speeds. The wheel described is known as the "mansel" wheel. The Wagon Shop is under the same roof as the sawmill. A variety of vehicles are seen here, the ordinary mineral wagon being perhaps the predominant type. We note a number of these in various stages of construction, the under-frame made of oak and the body made of pine. They are fitted with side doors and an end door, the end door being for shipping purposes.

Having been over and made ourselves acquainted with the works, we find ourselves in the Running Sheds. The first thing noticed by the visitor here is the sudden quietness after the din in the shop. Over a hundred engines are here at times. The right moment, however, to find the sheds really "in blossom" is on Sunday, when they are full of locomotives of every description. The engines as they come in off work "fall in" what is called the "ash lye." There her driver, after examining her, and inserting in the "driver's daily report book" any repair (if any) he wants done, makes out his report, which terminates his day's work. His engine, however, before she gets her rest, has her fire drawn, smoke-box cleaned, tender coaled, ash-pan cleaned, and finally the engine turned if any repair has to be executed. The engine when finally allowed to rest is cleared and made ready for her next spell of work. All the driver has to do when he "books on" is to oil and examine her, fill the water tank, and away for his train.

At each of the large running sheds there is a complete break-down train, consisting of a crane, tool-van, and a wagon for carrying blocks of wood.

The North British Railway Company possess numerous cranes suitable for running along the main road, three different sizes being used. For any light work the five-ton crane is utilized, but in case of break-downs, where one has ten or twenty wagons to lift, although the ten-ton (manual) crane will usually suffice, the big steam crane will lift them like so many boxes, and place them wherever needed. To give the reader some idea of its strength, it will lift a six-wheeled tender of a locomotive *en masse* and place it on the rails. "Jumbo," as the



TWENTY-TON CRANE READY FOR THE ROAD.

MAIN LINE PASSENGER ENGINE

crane is generally named, was not made at Cowlairs Works, but supplied to the Company by Messrs. Forrest and Company, engineers, Glasgow. When not needed, it is stationed at Cowlairs, being always kept in readiness for an emergency. If anything happens, and she is wanted, all that is necessary is that the crane-man should light his fire, so that by the time the crane is called upon to work steam is up and she is ready.

Another requisite of the road is a snow-plough. Several of these are distributed over the system. They are substantial timber structures. The buffer-beam of a goods engine being removed, a snow-plough can be readily fixed. An engine thus equipped looks like a foreigner with a "cow-catcher." To resist the weight of the snow, it rests upon the rails by means of a special arrangement.

The locomotives of the Company number, all told, 763; engine numbers run up to 692, but there are besides these 71 in the "A" list. The photographs represent the standard types of locomotives employed. The main line passenger engine "592" was exhibited in the Edinburgh Exhibition, 1886, and Mr. M. Holmes, her designer, obtained a gold medal. She is of the four-wheeled coupled bogie pattern, and fitted with all the latest improvements, including a sight-feed lubricator, which with very little attention automatically supplies the cylinders and valves with oil.

The dimensions of the engine are :—

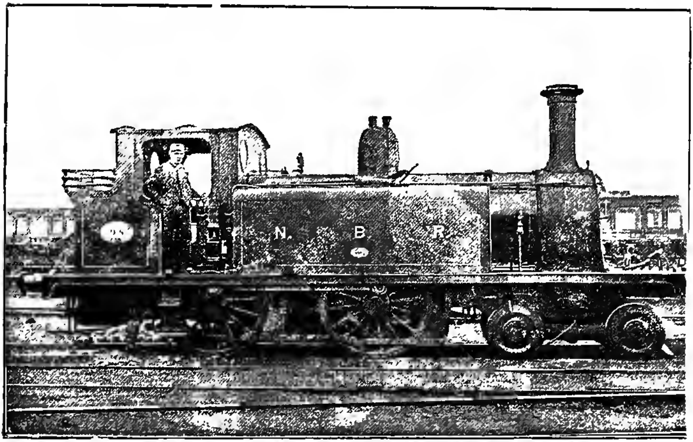
Diameter of cylinders	18 inches.
Length of stroke	26 inches.
Diameter of driving wheels	7 feet.
Total length over buffers	52 feet 9 inches.
Working pressure of steam	140 lbs. per sq. inch.

Heating surface of boiler:—			
Tubes	1007·0 square feet.		
Fire-box	119·0 ,, ,,		
Total	1126·0 ,, ,,		
Grate area	21·0 ,, ,,		
Weight in working order—	tons	cwts.	qrs.
Engine	45	5	0
Tender	32	0	0
Total	77	5	0
Weight on driving wheels	15	12	0
Water capacity of tender	2500 gallons.		
Coal ,, ,, ,,	5 tons.		

As may be remembered, "602" of this class had the honour of being the engine used at the opening of the Forth Bridge, when his Royal Highness the Prince of Wales drove in the last rivet. The Marchioness of Tweeddale drove the engine across the bridge.

In 1890 Mr. M. Holmes built at Cowlairs some more four-wheeled coupled bogie tender engines of the "633" class. These have 18 in. × 26 in. cylinders and a 6 ft. 6 in. driving wheel, the external appearance being similar to the "592" class. These engines generally run between Glasgow and Perth, when sixty miles an hour is a speed common to each run.

There are four classes of passenger tanks. No. 98 shows a small bogie tank which works the suburban traffic. These engines have 16 in. cylinders with 22 in. stroke, driving wheels 5 ft., and bogie wheels 2 ft. 6 in. in diameter. When built, some were fitted with a pump, and condensed their own steam, but this has since been removed. Another class of passenger tank engines worthy of mention are those built by Messrs. Nielson and Co. in 1876 ("494" class), having cylinders 17 in. diameter and 26 in. stroke, with a driving wheel 6 ft. in diameter. They carry 950 gallons of water and about 30 cwt. of coal, the weight in working order being 47 tons 4 cwt. Another class of engine very similar to these are the standard heavy passenger tanks ("586" class). These engines have cylinders 17 in. diameter and 24 in. stroke, driving wheels 5 ft. 9 in. diameter,



SUBURBAN PASSENGER TANK ENGINE.

water capacity of tanks 1281 gallons, the coal bunk holding $2\frac{1}{2}$ tons of coal; weight in working order 50 tons 7 cwt.

The fourth class is very similar to the London, Brighton, and South Coast Railway's "Terrier" type, being a small side tank engine, with cylinders 15 in. diameter and 22 in. stroke, driving wheels 4 ft. 6 in. in diameter, water capacity 600 gallons, weight in working order 33 tons 10 cwt.

The six-coupled tender engine (No. 666) represents one of Mr. M. Holmes' standard 18 inch goods engines. The following are the chief dimensions :—

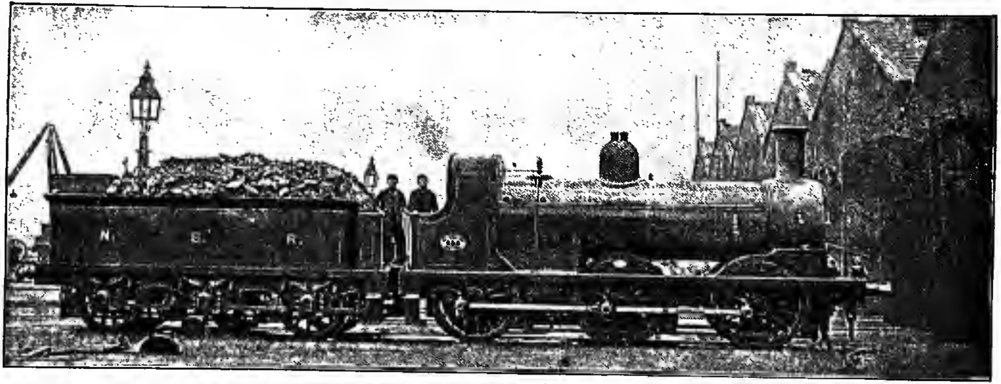
Diameter of cylinder	18 inches.		
Length of stroke	26 inches		
Diameter of driving wheels	5 feet.		
Total length over buffers	48 ft. 10 in.		
Heating surface of boiler—			
Tubes	1139·96 square feet.		
Fire-box	104·74 ,, ,,		
Total	1244·70 ,, ,,		
Grate area	17·0 ,, ,,		
Weight in working order—	tons	cwts.	qrs.
Engine	40	13	0
Tender	32	0	0
Total	72	13	0
Weight on driving wheels	15	8	0
Water capacity of tender	2500 gallons		
Coal ,, ,, ,,	5 tons.		

These engines work the heavy goods and mineral traffic, and are capable of taking fifty loaded wagons behind them.

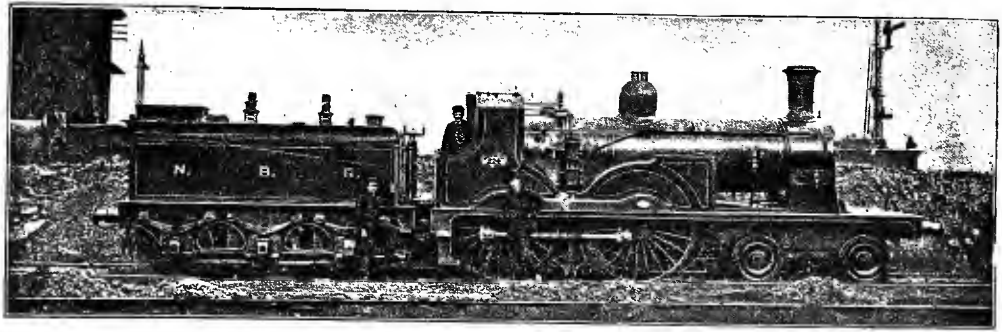
The small engine "146" illustrates one of Mr. M. Holmes' small shunting tanks for working yards, &c. They have cylinders 14 in. diameter and 20 in. stroke, driving wheels 3 ft. 8 in. diameter, wheel base 7 ft., weight in working order 28 tons 15 cwt., and water capacity 720 gallons, the side bunks carrying a small supply of coal.

The standard pressure adopted in all the new engines is 140 lbs. per sq. in.

Before leaving the engines I must say a few words about the "Edinburgh and Glasgow singles," as they are called ("214" class). These engines were built in 1856 by Beyer and Peacock, Manchester, Mr. Paton



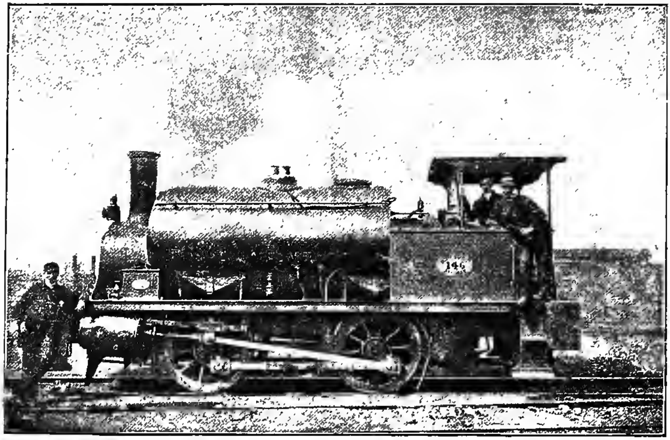
EIGHTEEN-INCH STANDARD GOODS LOCOMOTIVE.



PASSENGER ENGINE, BUILT 1871, WHICH FELL INTO THE TAY IN 1879.

being locomotive superintendent at the time, for running the main line traffic between Glasgow and Edinburgh. They have since been rebuilt and fitted with the Westinghouse brake, and are still running at their original posts.

The engines have cylinders 16 in. diameter and 22



SMALL SHUNTING TANK ENGINE.

in. stroke, driving wheels 6 ft. 6 in. diameter, with a small leading and trailing wheel both 3 ft. 6 in. diameter, weight in working order 27 tons 10 cwt. The passenger engines which travel up the incline from Queen Street to Cowlairs have their draw-hooks inverted. By this arrangement the connection between the train and the wire rope automatically releases itself, thus avoiding any stoppage to disconnect at the top of the incline.

THE END.

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