HOW ENGLISH LOCOMOTIVES ARE MADE.

The works at Crewe consist principally of a rolling mill for the manufacture of permanent way rails, and engine works for the manufacture and repair of the locomotive stock of the line. The latter, first opened in the year 1843, in connection with the then Grand Junction line, have been extended from time to time to meet the requirements of the traffic, until, with the rolling mill, they now cover upward of seventeen acres of ground, not less than 30,000 square yards of this being taken up by covered or workshop area alone.

At the *forge* connected with the engine works, the engine tires, axles, and heavier forgings, such as wheel spokes, rim pieces, coupling and connecting rods, together with fire-box roof stays and portions of the motion, are forged ready for the smith to finish.

The method of welding the wheel-spokes—required for the solid wrought-iron wheels—to the rim pieces is this: the spoke, already hammered to shape, and the outer end heated to a welding heat, is dropped between a pair of dies placed under the hammer in lieu of the usual anvil block, and held in a vertical position, with the heated end projecting about an inch past the face of the dies. On this, the rim piece, also heated, is laid, the two being welded firmly together, and dressed on the edges and rim in a few blows. Of the grate bars used in the locomotive fire boxes, about 800 tuns are used per annum; and for rolling this and the smaller sections of bar iron there is a ten-inch train rolling mill, driven by a double cylinder horizontal engine, built locomotive fashion, with longitudinal frames of cast iron carrying the crank shaft, and between which the cylinders are bolted, the whole resting on a stone foundation.

Passing on to the *smithy*, visitors may see the method of forging the solid wrought-iron wheels. The spokes with their attached portion of the rim, are here welded together at the but ends to form the boss, in such a manner as will form a segment of the intended wheels. These segments are then laid together, a hoop passed round the rim, the whole tightened up, and the welding of the boss center completed, thus forming one solid mass, independent of any further operation. The boss, which, from the ridge shape of the but end of the spokes, is dished on each side, is then heated and laid on the anvil of a steam hammer. A disk, or boss-plate, also heated, being laid on the boss, is first struck by the hammer (the head of which is of small diameter), on the center, so as to curl up the edges, and allow the scoriæ to be driven out, and then hammered round the edge by a number of rapid blows, the wheel being turned round on the anvil for that purpose, the operation being repeated for the other face of the boss; the whole is then dressed ready for the lathe.

The arrangement of the hammer, specially adapted for the pupose of "bossing," consists of a pair of cast-iron girders, between which the steam cylinder is bolted. These girders, are carried by cast-iron columns at the ends, and are of sufficient span to allow the space round the anvil block for manipulating the wheel. The hammer weighs about 10 cwt., and is double acting.

A similar arrangement is used for welding the plates required for the locomotive frames. The circular hearths, used for bossing and heating the frame plates, are placed under the girder so that the wheel or plate can be lifted direct from the fire to the anvil. To the framing fire has been fitted a deflector, which can be raised or lowered at pleasure, consisting of a plate bent down the middle of its length to about a right angle, and lined with fire bricks. The ends of the plate to be welded are laid four inches apart in the fire and the deflector lowered; the flame rising from the fire strikes the incline sides of the deflector, and is thrown back on the top surface of the framing plate, which is free from fuel producing a welding heat in a very short time.

The forge and *smithy* have an area of about 5,000 square yards. There are, altogether, fifteen steam hammers, varying from six to fifty cwt., and over 100 smiths' hearths, about twenty of which are employed in wheel making alone. Some idea of the amount of work done may be gathered from the fact that at present over 4,000 tuns of scrap iron, in addition to the ordinary merchant bars, are worked up annually.

The *boiler shop*, contiguous to the smithy and forge, consists of a main building down the sides of which the boilers in course of erection, and the bending rolls, punching, shearing, and other machines, are arranged, the whole being traversed from end to end overhead by a traveling crane. The smiths' hearths, steam riveting machine, and the tender-tank shop occupy wings at each end, while in the adjoining yard are placed the plate-heating furnace and bending blocks, and in addition to the manufacture of tender tanks, ordinary repairs, and other work, over 120 locomotive boilers are turned out per annum from this department.

The traveling crane consists of transverse hollow or box girders of plate iron, at the ends of which are fixed the carrying wheels. The longitudinal roadway is made of the ordinary permanent way rail, carried by cast-iron brackets bolted to the side walls, the crab running on rails riveted on the top web of the transverse girders. The method of driving is an arrangement of Mr. Ramsbottom's, first adopted in this crane, but which he has since carried out to a greater extent in other parts of the works. It consists of an endless cotton cord of small diameter, and very light, driven at a high velocity, and running down the ship on grooved slippers or guides, pulleys being dispensed with. From this cord, which in its course is carried across the traverser, all the motions are taken. Attached to the crab, and under the control of the attendant, is a sliding bar carrying two pulleys, between which the cord runs; by this means he is enabled to deflect the cord, and press it into grooves cut in the edge of a horizontal wheel, the motion thus communicated being afterward reduced through a train of worm and spur wheels to the chain barrel. The reverse movement is obtained when the cord is applied on the opposite side of the wheel, and a second, or quick speed, by means of another groove of less diameter cut in the same wheel. The cross and longitudinal motions are worked in a similar manner. This crane lifts a weight of six tuns at the rate of 4 feet 6 inches while moving across and down the shop, at the rate of 50 feet per minute.

In the *fitting* and *turning* shop, the various details of locemotive work may be seen in process of manufacture, from the forged to the finished state, there being nearly 200 machines of all descriptions, from the small bolt lathe or nut-cutting engine to the cylinder boring mill. The engine cylinders are here bored in pairs, the different machines being so arranged as to be within the range of a wrought-iron jib crane placed near them. After planing, the cylinders are removed to a template, consisting of a base plate carrying cast-iron standards, between which the cylinders are dropped, the bolt holes in the cylinder flanches being marked by corresponding holes in the standards, such accuracy of work being thus obtained as to allow of damaged cylinders being replaced by others in a finished state, without additional fitting, and which has been done in several instances. After the bolt holes have been marked and drilled, the cylinders are fitted with steam-chest covers, glands, etc., and bolted together. The lifting and moving about of the cylinders in this stage of the work is effected by means of a long shaft overhead, from which chains are suspended at the different points required, the cylinder or other object being raised or lowered by the revolution of the shaft, which can be started or stopped at pleasure. This is a good example of a cheap and serviceable crane, where power is applied at different points.

This shop is also fitted with a number of auxiliary tools, specially designed by Mr. Ramsbottom for these works; among others, is a machine for squaring bolt holes in cylinder covers, pipe flanches, glands, etc. This machine, which is simple in arrangement, consists merely of an upright girder, to which is bolted a long socket. In this socket slides a vertical forcing ram, with the end recessed to receive the point of a taper-toothed drift, the entering end of which fits the hole to be squared. The cover, or other object, is carried by a table bolted to the upright. The machine is driven in the usual way, and forces the drift through at one stroke of the ram.

[This seems to be a little behind the times. When such bolts were made with square shoulders on, to screw them in by, this might have been desirable; but we make our stud bolts round in this country and screw them in either with a nut made on purpose or two nuts jammed face to face on the thread.—Eds. Sci. Am.]

The short copper bolts used to stay together the inner and outer shells of locomotive fire-boxes, after being cut to length in the boiler shop, are here straightened and centered at each end. The tool used for this purpose consists of three rollers, one of which is movable on an eccentric spindle, so as to allow of the bolt being dropped in between them, when the movable roller forces it into contact with the other two, while a pair of square centers are simultaneously brought to bear on the ends. The stay, thus straightened and centered, is dropped out underneath, and is found sufficiently true to allow of its being chased in the lathe without further preparation.

The *spring smithy* is fitted with furnace and machinery for the manufacture of the locomotive engine and other springs used by this department. The steel from which the engine springs are made is received in long bars, which are first cut by a small shearing machine into plates of required length. The center of the plate being then heated, is indented by a conically-pointed punch fitted to the same machine, a nipple or projection being thus formed on the other side; the ends are then heated and passed between eccentric rolls, which at each revolution strike the plate and taper it down. The ragged ends are afterward cut off. The nipple referred to, dropping into an adjustable stop, attached to the machine, serves as a guide for the length. The plates are then bent to shape, hardened, and tempered down in the usual manner, built up into the complete spring, and the buckle shrunk on, the plates being prevented from moving endways by the nipple of one plate fitting into the corresponding recess of the one below it, which thus dispenses with a center bolt and the consequent weakening of the plates. To supply the new engines and keep up the repairs during twelve months, about 10,000 springs of all kinds have to be manufactured.

This shop has been fitted with several portable tools designed by Mr. Ramsbottom, for the purpose of boring cylinders, dressing the steam port faces, and axle box girders, when worn. These machines are driven by cords off the line of shafting moving down the center of the shop, and are so arranged that all the operations may be performed without moving the engine from its berth, or in any way disturbing the parts to be acted on.

The cylinder boring machine consists of the ordinary boring bar, to which the boring head is keyed fast and driven by worm wheels. The driving pulleys are made in two halves, so as to be applied at any point in the length of the line of shafting.

The *erecting and preparing shops* turn out per annum about 100 new engines, and keep in repair the greater part of the stock, which at present exceeds 11,000 engines, the average number of those under treatment amounting to 100.

The tender, joiner, and pattern shops, are situated in another part of the works.

In order more effectually to knit together these works, which spread over a great surface, a tramway has been laid down at 1′ 6″ gage.

The tramway is now about three-eighths of a mile long, and is worked by a small locomotive engine named *Tiney*. In its course it traverses curves of 15 feet radius each, no difficulty being found in going round these curves with loads of twelve to fifteen tuns, or in taking 7′ 6″ wheel forgings or tires on edge, by means of trucks specially adapted for the purpose. This engine has four wheels coupled, inside cylinders 4¼ diameter, and 6″ in stroke; the wheels are 15 inches in diameter on a base of 3 feet. The total heating surface is about forty-two square feet; the boiler is fitted with a No. 2 Giffard's injector, and carries a saddle tank capable of holding twenty-eight gallons. The total weight, in working order, is 2½ tuns. The line is in most cases parallel to the ordinary rails in the works, and the engine is used to fly-shunt the large wagons in all cases where it can be brought to bear.

The *Pell*, of similar construction to the *Tiney*, has been constructed for the use of the steel works.

The total number of hands employed upon the Crewe establishment is about 4,000, of which number about 3,300 are employed in the locomotive works.

The London and Northwestern Company disburse weekly the sum of £3,500 in wages to the mechanics and others engaged on these works. The following items, from the account of materials issued from the stores at Crewe, for the twelve months ending May, 1863, will convey some idea of the magnitude of the operations:—Finished brass, 67 tuns; rough brass, 234 tuns; brass tubes, 331 tuns; sheet, bar, and other copper, 244 tuns; iron rails, 13,849 tuns; steel rails, 2,206 tuns; sheet iron, 1,986 tuns; bar iron, 1,272 tuns; oak timber, 85,241 feet; various timber, 1,220,607 feet. The shops connected with the locomotive department cover a space of 26,336 square yards; and the rail works, including the yard, occupy 13,302 square yards. The extensive consumption of water at the works and the neighboring station is met by the conveyance, from Whitmore, a distance of eleven miles, of the produce of a well sunk in the red sandstone. This water is remarkable for purity, containing only about five grains per gallon of foreign substances, and no organic matter, which renders it specially applicable to engineering purposes. The total consumption amounts to between 600,000 and 700,000 gallons per day. In the neighborhood of the main works is an establishment for the manufacture of the peculiar yellow grease whose appearance is familiar to all railway travelers, the whole requirement of the London and Northwestern Railway Company in this article being furnished by the Crewe Works.—*Ryland's Trade Circular.*

Correspondence.

Sandpaper Finish.

MESSRS. EDITORS:—I could not repress a smile as I read in my SCIENTIFIC of September 30 the description of E. J. W. of his "solder chuck." The sticking point, viz., how to remove the soft solder from the disk of sheet metal, he passes over rough-shod and in the most unworkmanlike manner. What would a good workman think of doing a fine job and "finishing" with sand paper? His "solder chuck" would undoubtedly hold true, but he must devise some better way than the use of sandpaper for finishing. He cannot do it in the lathe, for he has no means of holding it.

I have heard English mechanics "slur" American work, styling it "deep scratches and high polish." It is certainly humiliating to an American to hear one who is admitted to the columns of our great scientific journal advise the use of sandpaper as a finisher. M. L. B.

Kane Co., Ill., Oct. 1.

[If our correspondent will try the effect of 0-sandpaper covered with chalk on any metal that has been well finished previously, we think he will not be disappointed with the result. English mechanics have good reason to complain of some American work on account of the "Buffalo finish," as it is sometimes called; but we noticed, on examining the *Great Eastern* engines that, for some cause or other, great patches of scale or hammer marks had been left in the principal finished parts, which certainly did not improve their appearance.—EDS.

Melting Wrought Iron.

MESSRS EDITORS:—In the SCIENTIFIC AMERICAN of October 7th, you state, in reply to your correspondent, A. P. W., of Wisconsin, "That when the carbon is all burned out of cast iron by the Bessemer process, the metal is brought to a state of pure wrought iron in a molten condition."

I have been a close observer of the manufacture of wrought iron in this place, for a number of years, and have never yet seen "wrought iron in a molten condition," and do not think it possible for it to exist in that shape. I have been informed by practical manufacturers of wrought iron, that when cast iron has been sufficiently decarbonized to become wrought iron, it ceases to be a fluid, and then, by adding sufficient carbon to make it fluid, it becomes cast steel. I am aware that in the Bessemer process of making steel they burn out of the cast iron as much of the carbon it contains as possible, and, by adding a percentage of molten cast iron containing a proper amount of carbon, the mass in the converter becomes molten cast steel, and, as such, is poured into ingots. But that the mass obtained by decarbonizing cast iron in the open converter of Bessemer, is wrought iron in a molten state, I cannot yet understand; for if so, why not dispense altogether with the present style of puddling furnaces and manufacture wrought iron by the pneumatic process? It would be cheaper, require less labor, and be quicker done than puddling—the present way of obtaining wrought from cast iron. If wrought iron could exist in a molten condition, could not molds be filled with it, and in that way produce wrought-iron machinery without the labor of forging?

I once tried to melt wrought iron in the following manner:—I filled a black-lead crucible with small pieces of wrought iron, and, making the lid on it as near air-tight as possible, I subjected it to an intense heat for several hours; I then made a small hole in the lid for the purpose of pouring out the molten iron, when a stream of flame burned intensely from it for a few moments, and then ceased. I removed the lid and found my crucible filled with cinder.

I was told by a scientific gentleman that the oxygen of the air, which the hole permitted to enter, combined with the iron, burning it up, leaving nothing but the oxide; if that is so, then wrought iron cannot exist in a molten condition to be of any practical use, as contact with the air would immediately destroy it. J. E. F.

Johnstown, Pa., Oct. 9, 1865.

[We have seen a rod of wrought iron, under the action of a powerful galvanic battery, grow first red at the end and then white, and finally fall in liquid drops apparently as fluid as water. The melting point of pure iron is stated by Booth and other authorities at 2,850° Fah., but as in the case of many other substances, the melting can be effected only when the metal is sheltered from the atmosphere, for even at a red heat the affinity of iron for oxygen is so great that the two substances instantly combine when brought in contact, forming oxide of iron. There is no pyrometer that will measure temperatures so high as 2,850°, and the real fusing point of pure iron must be regarded as undetermined; some authorities estimate it as high as 6,000° or 7,000°.—EDS.

THE HOOSAC TUNNEL.

The progress on this work appears to be somewhat delayed, it does not drag its slow length along at all, and public attention has lately been directed to the causes. Mr. F. W. Bird writes a long article to the Boston *Advertiser*, wherein he foots up a long array of errors, etc., against those having the work in charge. We make such extracts from this paper as our space will allow:—

"The materials near the surface of the ground, and for a short distance in the shallowest part of the open excavation, are common earth and hard pan. These gradually change into a substance that is neither earth nor rock, in any common acceptation of those terms. The most appropriate name I heard it called by was 'demoralized rock.' In its normal condition it is tough and hard, like rock, but when exposed to the combined influences of air and water, it runs away like quicksand; or, if pent up, it becomes 'porridge.' It abounds in seams, or crevices, from which issue numerous springs and little streams of water. The one hundred and ten feet of heading accomplished at the west end required a stout framework, or lining of heavy timbers and planks, to be set up as fast as the excavation was made, in order to resist the pressure and weight of the surrounding material. At first the progress here was fair. This favorable state of things continued for a few days, when the quantity of water began to increase, 'demoralizing' the rock, and converting it into an unmanageable fluid, which could neither be drained, nor shoveled, nor pumped. Pouring down from the top, rushing in from the sides, boiling up from the bottom, in a few days it had let daylight through the forty feet of roofing. Owing to the peculiarity of this material before referred to, it will stand vertically at almost any height so long as it is dry; whereas, as soon as the water touches it, it is disintegrated or worse, if possible, than the worst quicksand.

"The nature of the difficulty may be inferred from the fact that this bad material was struck in December last, nine months ago, and since then the whole progress made, with indefatigable labor by as many men as could work in the cramped quarters, inclusive of the advance of three or four feet a day at first, has been one hundred and twenty-five feet! The managers are at their wits' ends. Indeed, despondency broods over the whole western side, relieved only by the forlorn hope that 'something will turn up' in the shape of a feasible contrivance for confining the slippery material. It is, as one of the workmen said, 'Be jabers, ye might as well try to shovel a cart load of live eels!'

"As a last resource, it was decided to continue the open cutting on a level passing above the top of the tunnel, until the point directly above the largest spring was passed. A stout timber frame work, some twenty feet long (similar in construction to the cribs used in deep-water foundations for masonry,) having the sides and forward end planked, but open at the bottom, was then placed over the spring and forced down into the fluid mass until it came to the bottom line of the tunnel. A plank flooring was next added to the crib, and a timber roof is now being constructed to make the finish of this portion of the 'heading' correspond with the part which was really made by horizontal excavations.

"Having groped along thus far in the solution of the ugly problem, the next question seems to be how to remove the plank and timbers from the forward end of the crib, and yet stay the rush of 'porridge' from all directions into the opening. When the crib was put in, the planks at the forward end were hard up against the rock. Since then it has been found by boring through this planking, that the rock has become 'demoralized,' and that there are three or four feet of 'porridge' between the planks and the face of the rock. How to get that 'porridge' out nobody knows; and how, in case they can dip out the 'porridge' already formed, they can extend the crib forward, and make tight joints on the sides, top and bottom, against the rock that is yet hard, is a still more difficult problem; and this accomplished, there remains the incalculably greater difficulty of keeping the face of the rock open for work without the rush of 'porridge,' which all experience has hitherto shown will instantly form upon the exposure of the surface of the rock to air and water. Engineering resources may, and perhaps will, prove a match for the emergency; but common men, and some uncommon men, too, look upon these difficulties as insuperable. The prevailing opinion is that our State treasury is bottomless, and, therefore, that, somehow or other, in some time or other, if money enough is forthcoming, science, skill, and perseverance will triumph.

"It will at once be asked, How far does this material extend? About half a mile from the west face is the West Shaft. This shaft was sunk by Mr. Haupt, and he excavated some forty or fifty feet of tunnel in each direction. When the heading had advanced two hundred and eighty feet westerly, the workmen struck a material similar to that at the west face, accompanied, as there, with water. Finding the water increasing very nearly to the full capacity of the pump, and finding also the same tendency to 'porridge,' and confident that the water would speedily become greater than their means of pumping, and thus stop the work on the eastern face of the shaft, it was decided, as a matter of expediency, to discontinue the work on the west face in the shaft. Between this point and the west end of the tunnel, (that is, where the crib is), the distance is twenty-three hundred feet! Artesian borings have been made at different points on the way, all showing the same material. These facts give the data of the problem. They have been nine months advancing one hundred and twenty-five feet under a bank some forty to sixty feet high; and they have got along so far only by removing substantially the whole mass, and making an open cut. How long, at this rate, will it take to advance 2,300 feet, especially if they have to make an open cut running rapidly from sixty up to three hundred feet? And what will it cost, either to tunnel that material, or to make an open cut, with slopes that will stand?"

PNEUMATIC DRILLS.

"But whenever exception is taken to the slowness of the progress, we are told, 'Oh, wait till we get the pneumatic drills at work! then you'll see the chips fly!' Well, we have waited quite patiently. Nearly two years ago the money was sent abroad to purchase drills of the kind used at the Mont Cenis Tun-