

at high temperatures up to 100°. These will be found useful in practice, and much superior to those hitherto constructed of gutta-percha or other insulators, and which were of comparatively slight use in accurate work, owing to absorption, change of resistance with temperature, and inconstancy when kept for any considerable time. The determination of a unit of capacity has occupied Dr. Matthiessen, Mr. Hockin, Mr. Foster, and Mr. Jenkin, during the past two years. Very considerable difficulties have been encountered, some of which are not yet wholly overcome. The methods by which both the electro-static and electro-magnetic units can be determined, and multiples or sub-multiples prepared, are sufficiently simple in theory; but they assume that the condensers or Leyden jars compared have really a definite capacity, and that, with a given electro-motive force between the induction surfaces, a definite quantity of electricity will be contained in the jar or condenser. This is very far from true with those of ordinary form. Whether the dielectric separating the plates be glass, mica, gutta-percha, paraffin, ebonite, or any other known solid insulator, an absorption of electricity takes place; the longer the plates are charged, the more electricity the condenser will contain; and, conversely, it will continue to discharge itself for a very long period after the inner and outer armatures have been joined. With some of the best insulators the effect will continue for hours, if not for days. Condensers made with these solid dielectrics have therefore no definite capacity, and such capacity as they have will differ according to the time during which they have been charged, and probably will also vary with extreme variation in the electro-motive forces employed, although this latter variation is not to be detected when the differences of potential are such as between one Daniell's cell and two hundred. Only one dielectric—air—is free from this embarrassing peculiarity, called "absorption polarisation," or "residual charge." The object of the committee has therefore been to construct condensers in which air alone separated the induction-plates; but new difficulties arose in carrying this idea into practice. Some support for such plate was necessary, and then leakage occurred from one plate to another over the surface of any small insulating supports employed, such as glass balls or vulcanite stems. It was possible, by great care in drying the air, occasionally to make condensers of this type, which would remain insulated for a short time; but long experience has shown that artificially dried atmospheres cannot be conveniently maintained in any instrument which is not hermetically sealed. Dust also accumulated between the plates of the trial condensers, and this altered their capacity, and increased the leakage from plate to plate. Even a single filament of dust, by springing up and down between the two electrified surfaces, would occasionally bring them to the same potential, and with great rapidity neutralise the charge; moreover, a condenser of this type could not be taken to pieces and cleaned, for no mechanical contrivances could ensure that the parts after cleaning would return to their original positions so exactly as to constitute a condenser of the same capacity. It is, therefore, clear that an air-condenser cannot be easily constructed. It is hoped, by the use of two plates soldered to metal rods and supported on insulated stems inside a soldered metal case, that these objections may be partly avoided; but, meanwhile, practical men have introduced condensers of a more convenient form, overlooking the disadvantages they all have of indefinite capacity. These condensers consist of sheets of tinfoil, separated by talc, or preparations of gutta-percha, or paraffin and paper; three plans adopted by Mr. Latimer Clark, Mr. Willoughby Smith, and Mr. Varley respectively. Condensers of this type have been made approximately equal to a knot of some submarine cable, and the rough units thus introduced are gradually creeping into use, although all electricians have been anxious that the committee should issue a more scientific standard. Under these circumstances, Mr. Jenkin has adjusted a talc condenser approximately equal to 10⁻¹⁴ absolute electro-magnetic units. The capacity of that condenser is assumed as that which it possesses after electrification for one minute, and is measured by the discharge through a galvanometer in the manner usually practised when testing the charge of a submarine cable. The formula for obtaining measurements in absolute units from the throw of the needle is very simple, requiring only an observation of the time of oscillation, of a resistance in absolute measure, and of a deflection of the galvanometer needle. All of these observations can readily be made, so that their accumulated error cannot exceed 1 per cent., and for the present purpose this accuracy is sufficient. While, therefore, the new provisional unit of capacity has no claim to a high scientific accuracy, it will supply a practical want, and introduce a unit based on the principle adopted by the committee. The practical application of the standard of capacity is important. It will allow the capacity of submarine cables to be universally expressed in comparable figures, and may lead to improvement by the diminution of the specific inductive capacity of the insulator, precisely as the introduction of units of resistance has assisted the improvement in insulation and conductivity. The electro-magnetic capacity standard will also, by comparison with the electro-static standard about to be made, furnish one mode of determining the constant, called v in previous reports, a number of much importance in the theory of electricity. The next unit, or standard, for consideration is that of the different potentials, or electro-motive force in absolute measure, concerning which

the experiments have been wholly in Sir William Thomson's hands. He reports that he has at last succeeded in constructing a series of electrometers capable of measuring differences of potential ranging from $\frac{1}{100}$ of a Daniell's cell up to 100,000 cells, and that these measurements can all be reduced to absolute units by comparison with one instrument of the series. This class of instruments has been created by Sir William Thomson, who year by year has produced electrometers each surpassing its predecessor in accuracy and delicacy, until the instruments now supplied surpass every expectation of practical electricians, and furnish a new engine for electrical research. The chief difficulties encountered have been the insulation of the Leyden jar, which has formed an essential part of all the contrivances, its maintenance at a constant potential, and the reduction to absolute measurement. In the present instruments, absolutely perfect insulation is no longer required, for, by a device for converting mechanical force into static electricity, the jar can be replenished by a few turns of a handle, and then, by a gauge electrometer, the same constant charge can be ensured. The difficulty of the reduction to the absolute units is in the comparison of the extremely small forces produced by electro-static attraction with the force of gravitation and in the accurate measurement of the extremely small distances which separate the attracting surfaces. These difficulties appear to have been overcome, as Sir William Thomson reports that he will shortly be in a position to construct and issue a simple pattern of an absolute electrometer, or gauge of potential, which will serve as a standard for general use. The replenisher, which is founded on the principle of the electrophorus, may very possibly supersede the old form of electrical machine entirely; it has some analogy with the electro-magnetic machines lately invented by Mr. C. W. Siemens, by which intense dynamic effects are evolved from the smallest initial trace of magnetism by the conversion of mechanical force into electric currents, and was suggested by that invention. A modification of the same contrivance will allow the comparison of extremely minute quantities of electricity, such as indeed might be contained on a pin's head. By a series of rapid inductions, a charge is accumulated on the electrode of an electrometer which may be exactly equal in potential to that of the pin's head, but may infinitely exceed it in quantity; the effect of this charge in the electrometer can then be observed without difficulty, and any increase or diminution in the quantity of electricity on the pin's head can be instantly detected and the rate of loss or increase observed. The potentials to which various small bodies are charged can also be observed by the same method, the advantage of which consists in the fact that the original charge on the body tested is wholly undisturbed by the test, whereas by any of the older tests the charge was altered by being touched by a proof plane or by the electrode of the electrometer. A similar plan has already been proposed by Sir William Thomson with a water-dripping arrangement, but the mechanical contrivance is in all ways preferable. Passing to the unit of current, the committee regret that no experiments have yet been made with the large absolute electro-dynamometer constructed from the funds granted by the Royal Society. Much difficulty has been experienced in finding a sufficiently solid foundation in London, and probably the instrument must be moved into the country for accurate use. A portable electro-dynamometer has been constructed which will be suitable for distribution as a standard instrument. It can be compared with the large absolute instrument, and can also be compared directly with the most sensitive astatic galvanometers yet made, as has been already proved by experiments. Sir William Thomson has also constructed an electro-dynamometer for absolute measure; his results will check those obtained in London, and the portable standard will also be tested by being sent backward and forward between Glasgow and London, to be compared alternately with the absolute instruments. The determination of v , the ratio between the electro-static and electro-magnetic units, is also an object pursued by the committee, and preliminary experiments have been made. Sir William Thomson has obtained numbers for this constant by the use of the absolute electro-dynamometer and the absolute electrometer before mentioned. The number he has obtained differs so considerably from that hitherto received, that he prefers to extend his experiments before publication. The like remark applies to the measurement of the electromotive force of a Daniell's cell made by the absolute electrometer. It will be seen from the report that the grants have stimulated further expenditure on the part of more than one member; and thanks are also due to the Electric and International Telegraph Company for the liberality with which they have lent large batteries, thereby saving much expense. The committee are willing to be re-appointed, and require no grant for the ensuing year.

ORNAMENTAL RAILWAY BRIDGES.

TO THE EDITOR OF ENGINEERING.

SIR,—There are few subjects that appear to deserve a more liberal share of professional notice and study than those which relate to what I may call the architectural effect of engineering works, and more particularly to railway bridges and viaducts.

The engineer of the Highland Railway has lately been showing a little of what should be done in this way, even in a sparsely inhabited country like the Highlands of Scotland, and it is to be

hoped that so good an example may not be lost upon the profession at large.

If some of Mr. Mitchell's bridges, of which illustrations have recently appeared in *ENGINEERING*, were placed side by side with many of the structures which disfigure and disgrace the metropolis, the contrast between what has been thought good enough for London and what has been done in the north would be surprising and instructive. On a former occasion I tried to point out that, in a great measure, the parish authorities, and not the engineers, are to blame in this matter; and I further ventured to express a conviction that if the former gentlemen would only abandon their absurd and mischievous predilection for "straight-girder bridges," and bestow their patronage instead on suitably constructed stone or brick arch bridges, engineers would have a much better opportunity of displaying some architectural taste in such works.

A striking illustration of what may be done in adapting the arch to the requirements of railway bridges over the streets of a town or city may be found in the French section of the Paris Exhibition. A model is there shown of a bridge, which was erected by M. Vaudray to ascertain whether a stone arch of 124 ft. span, with only 6 ft. 11 in. rise, would be sufficient for ordinary street traffic. The tests which this bridge sustained demonstrate that it is quite sufficient to carry any railway traffic that could be brought upon it; and although this is not, perhaps, the exact fact which this arch was built to determine, it is, nevertheless, a most important one, and strikingly confirms what I have previously attempted to show might be done in railway-arch bridges over streets, &c.

The first step in such an important reform as the substitution of arch for girder bridges in every case possible in the metropolis, where railway extensions are making such strides, would be taken if our parish friends burnt forthwith their pet clause about "ornamented straight-girder bridges," and substitute one requiring an ornamental flat stone or brick arch of the proper headway, having the soffit lined with a white glazed surface, or such other requirements for appearance and light as might be thought desirable.

There are, however, cases where, either from the perversity of "parish" nature or from other circumstances, a girder bridge must be the form adopted, and your remarks about malleable cast iron on page 298 of this volume of *ENGINEERING* remind me that I have a few words to say about the use of some such material as this in the ornamentation of wrought-iron girder bridges.

The first consideration which presents itself in designing an ornamental wrought-iron girder is, the difficulty in disposing of the material composing the girder itself, so as to obtain, without other aids, an ornamental structure; in other words, it seems to be almost impossible to ornament satisfactorily an ordinary wrought-iron girder without, in the first place, covering it over and hiding it altogether behind an ornamental screen or some such-like false exterior. This not unusual method of treating the girder is so entirely opposed to every essential principle of true design, that some feasible way of making the girder itself an ornamental feature in the design is most desirable, and it has occurred to me that a judicious use of malleable cast iron would accomplish such a result.

The destructive results which arise from wrought-iron work being inaccessible to constant examination and painting, when found necessary, are too well known to require notice here; and it is obvious that a girder which is covered with a false face cannot have these advantages, like one that is not so covered, nor, for the same reason, can a "box" girder be kept in such good condition as an ordinary single-web girder. A "box" girder, however, presents a better surface (having smaller projections at the flanges) for the "false face" treatment, and some very fair specimens of such girders may be seen on the city branch of the North London Railway.

The ordinary single-web girder, unburdened and free from false coverings and screens, would appear, then, to be the most desirable kind of girder to use for such cases as occur in general railway practice; and, of course, the question follows, how can such a girder be changed from its native unsightliness and converted into an ornamental feature of the design, while it retains all its capacity for work?

The outline of the girder is unpromising in itself, to begin with. We have the web, with top and bottom flanges projecting a foot or more, and, at certain intervals, upright stiffening plates, with the same, or nearly the same, projection as the flanges.

The flanges are so narrow or thin that nothing can be done without some kind of screen being attached to their edges; such screens, however, may be made to answer useful purposes without covering more than an inch or two of the real girder (viz., the edge of its flange). The top screen will be useful, and is often required as a screen, and the lower one will make a suitable connexion between the ends of the cross girders, which are supposed to be hung from the main girders.

The last features that have to be brought into a more promising shape are the upright stiffening plates, and it is here that I think malleable cast iron might be specially valuable. The thin boiler-plate uprights must be abolished altogether, as being totally inconsistent with any attempt at ornament, and the stiffening effected by means of suitable brackets or "knees," which, with screens, could be cast with any amount of ornament in malleable cast iron.

Although this is but a hasty sketch of the manner in which I believe a perfectly sound and, at the same time, handsome wrought-iron girder might be obtained, I have gone into the subject for my own information much more fully than I can attempt to do here, and I am quite satisfied, from what I have seen, that malleable cast iron of such a description as that manufactured by Messrs. McHaffie and Co., of Glasgow, will be found admirably adapted for the purposes I have indicated, and will also prove a great help to the engineer who wishes to produce honest, workmanlike, and, at the same time, ornamental girders, without using any false construction which he knows will ultimately lead to their destruction.

I trust these few rough notes on this very important subject may lead to its being a little more considered.

I am your obedient Servant,

J. S. M.

Westminster, October 8, 1867.

THE TWIN-SCREW YACHT "WOL" CONSTRUCTED BY MESSRS. LEWIS AND STOCKWELL, SHIPBUILDERS, BLACKWALL. (For Description)

FIG. 5

SCALE OF DISPLACEMENT

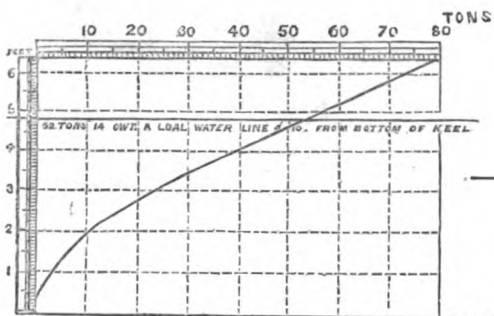


FIG. 6

BODY PLAN

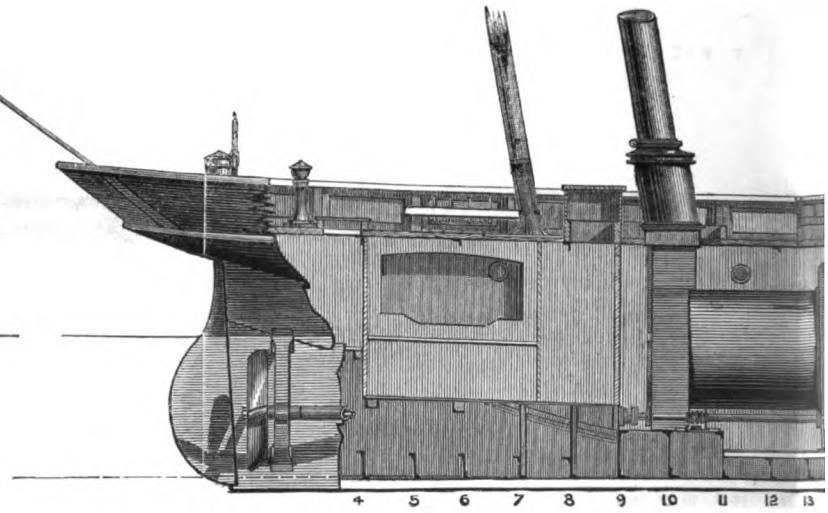
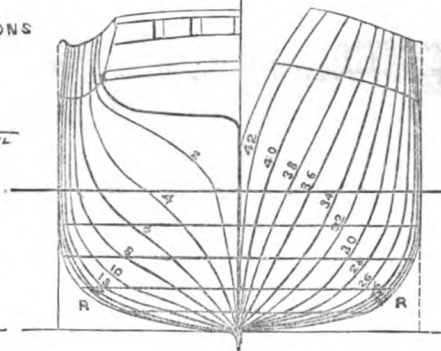


FIG. 7.

SECTION AT 2.

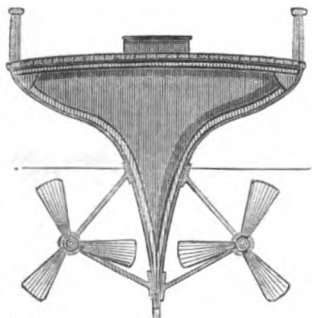


FIG. 8.

SECTION AT 10.

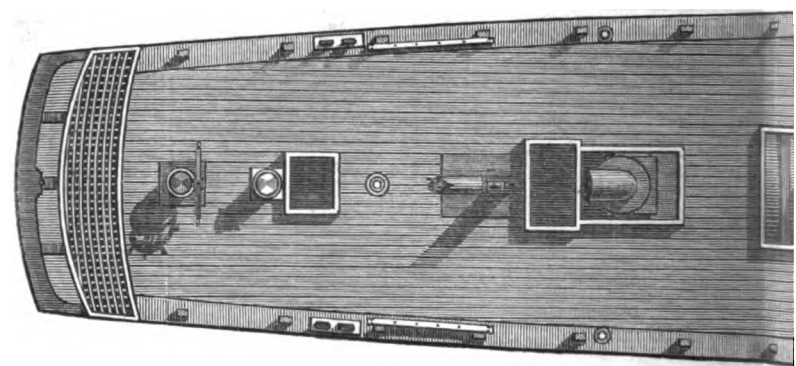
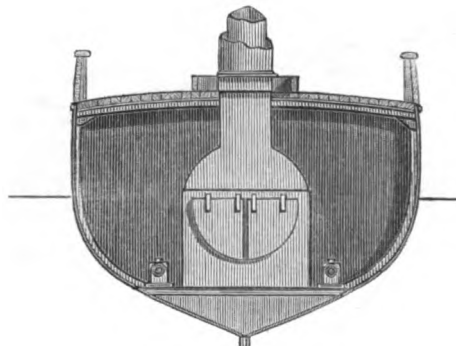


FIG. 9.

SECTION AT 18.

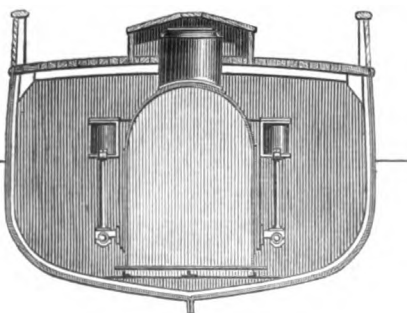


FIG. 10.

SECTION AT 24.

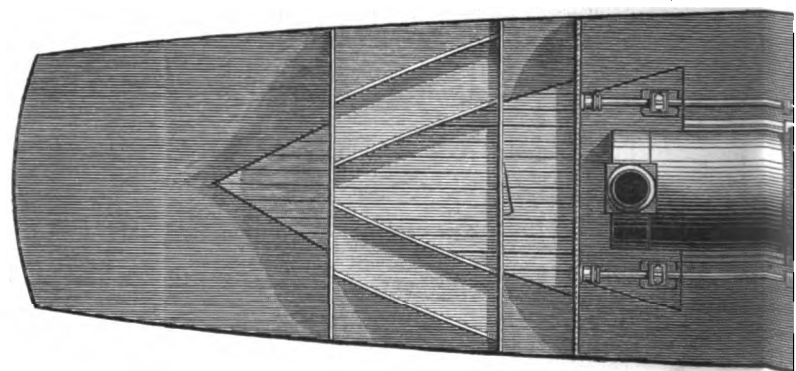
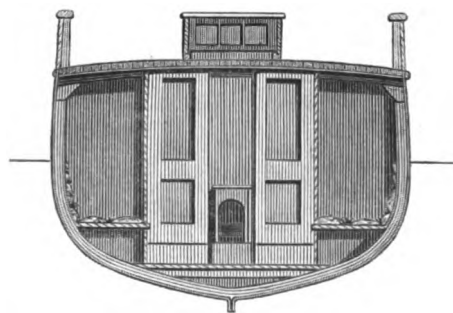
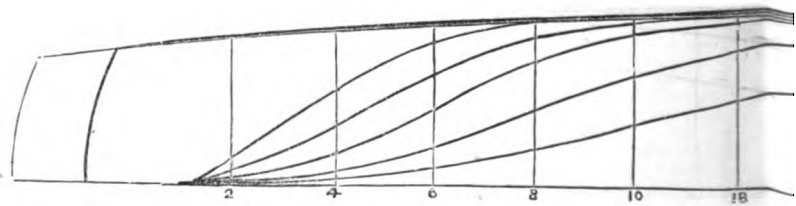
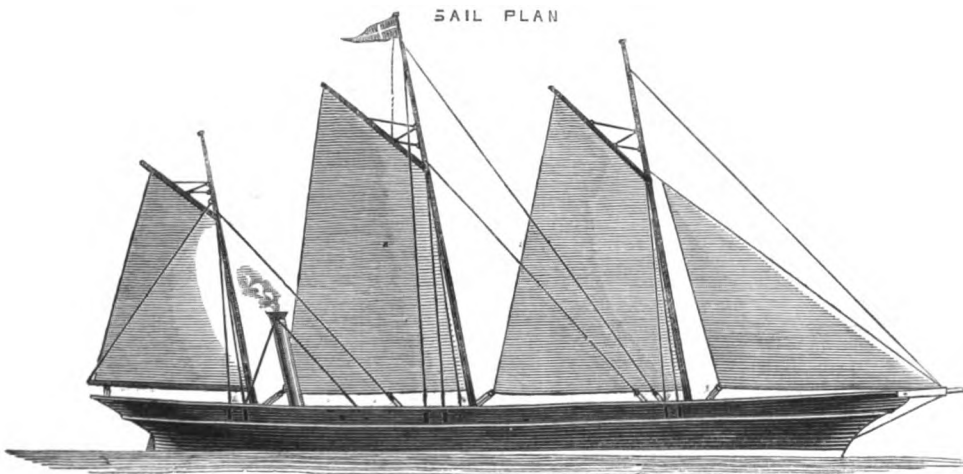


FIG. 11
SAIL PLAN



"LIVERINE"; 50 TONS BURTHEN.
 L, AND ENGINED BY MESSRS. JOHN PENN AND SON, ENGINEERS, GREENWICH.
 (see Page 369.)

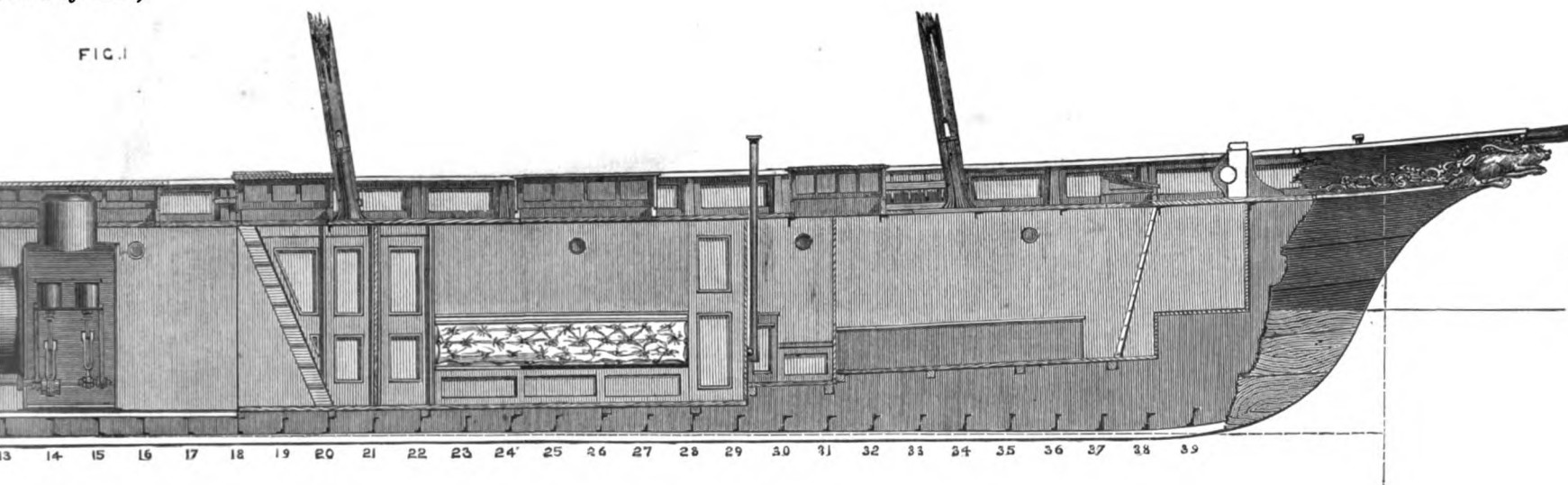


FIG. 2.
 DECK PLAN

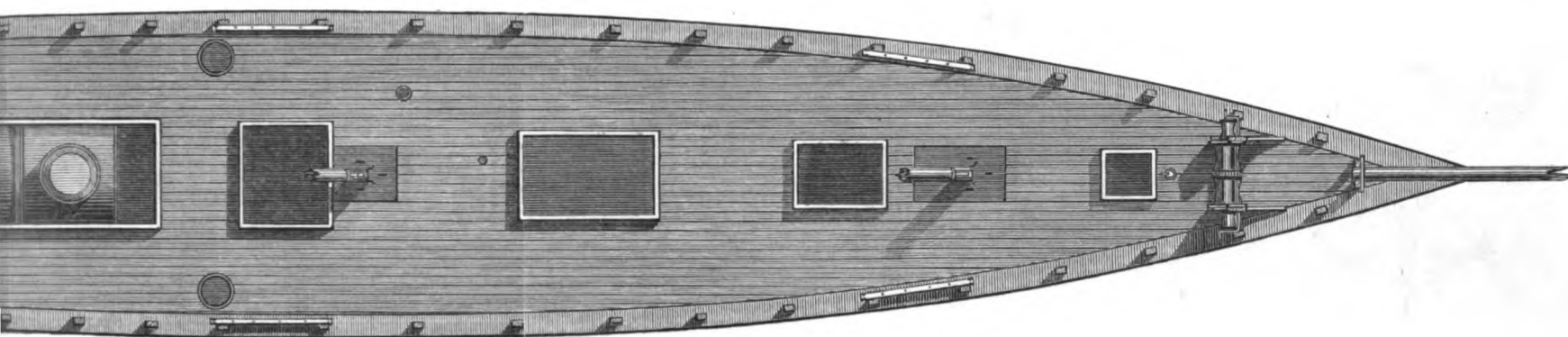


FIG. 3
 CABIN PLAN

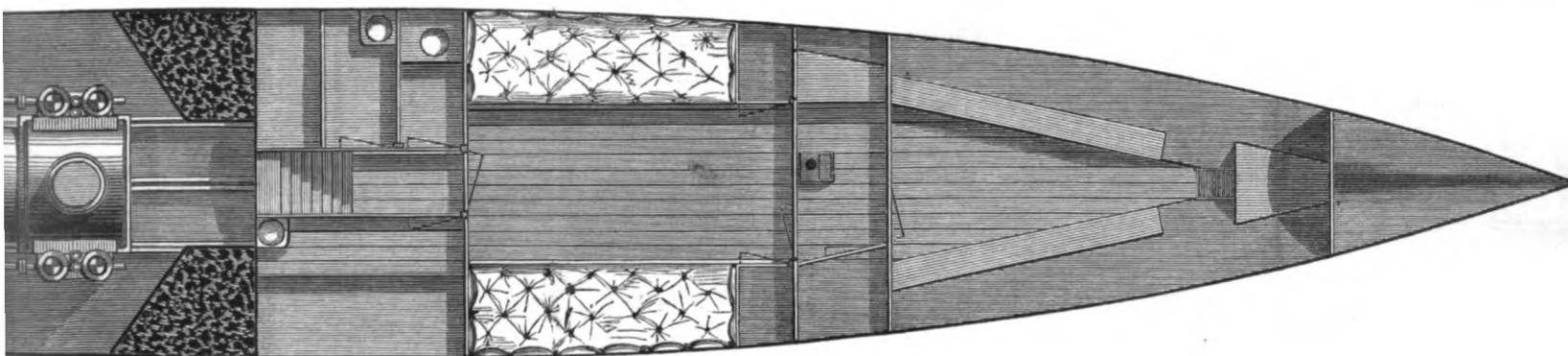
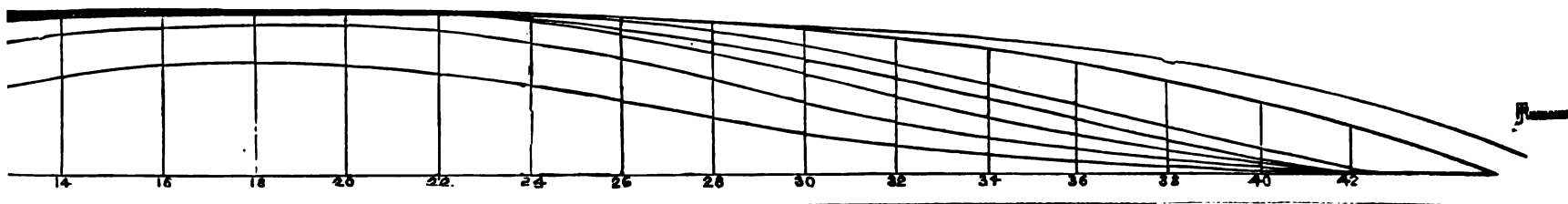


FIG. 4.
 HALF BREADTH PLAN.



TWIN-SCREW YACHT WOLVERINE.

THE pleasure navy of England may be regarded not only as a nursery for our sailors, but also as the means of allowing the trial, on a small scale, of many practical and valuable experiments in the build and equipment of vessels; and we are glad to observe that a considerable number of steam yachts are now attached to our principal yacht clubs.

This week we present our readers with a two-page engraving of the twin-screw steam yacht *Wolverine*, which has lately been built by Messrs. Lewis and Stockwell, of London, for Major Brandram. She is from the designs, and was built under the superintendence, of Mr. J. F. Delany, Assoc. Inst. C.E., and is of the following dimensions:

Length between perpendiculars ...	70 ft.
" over all ...	81 ft.
Breadth of beam ...	12 ft.
Depth from top of keel ...	7 ft. 6 in.
Draught of water (aft) ...	5 ft. 3 in.
Tonnage, 60 tons, yacht measure.	

The *Wolverine* is built expressly to take the ground in tidal harbours, &c.; she has, therefore, very little rise of floor, and is furnished with bilge-pieces formed of bulb iron, and rivetted to the plating by two angle-irons placed back to back. These bilge-pieces have the effect of both decreasing the rolling of the vessel, and also supporting her when on the ground.

The deck fittings are of teak, got up "bright" and varnished. The *Wolverine* is furnished with three pole-masts, which are made to lower, and are fitted into "tabernacles" of remarkably neat design; these tabernacles are of cast iron, and have long slots or mortices cast in them, in which the heels of the masts work upon through pins, as shown in the engraving. The mast-heels are also tenoned to fit the slots in the tabernacles, and in order that the heels should not be weakened by the wood being cut away, the tenons have straps or shoes of wrought iron passing entirely over them. This arrangement permits of the tabernacles being of the same diameters as the masts themselves; and as the "round" is carried down to the deck, there are no unsightly boxes to be observed round the masts when in place, as is the case with ordinary mast-lowering gear.

The steering apparatus is also a very ingenious contrivance, and is known as "Skinner's patent." It consists of a hollow column or cylinder placed directly over the rudder-head, this column containing an internal cylinder which is securely fixed to the rudder-head in a vertical position, and has two spiral grooves cut through it opposite to each other. A wrought-iron screw is hung from the outer column, and passes down the centre of the internal or grooved cylinder; on this screw is a nut having two arms forged on it, which project through the spiral grooves of the internal cylinder, into two vertical guides cast on the interior of the outer column. It will be readily understood that if the screw is made to revolve, it will of course move the nut either up or down in its guides on the outer column; and as the arms of the nut work through the spiral grooves of the internal cylinder, the latter will necessarily turn to an amount equal to the pitch of the spiral groove, this being fixed to the rudder-head communicates the desired motion. The top of the screw is furnished with a mitre-wheel, which gears into another on the hand-wheel spindle. This arrangement does away with all chains or other encumbrance, and leaves a perfectly clear deck all round the steering wheel.

The engines of the *Wolverine* are by Messrs. J. Penn and Son, of Greenwich, and are precisely similar in design to the smaller engines for steam launches supplied by that firm to H.M. Government, and of which a description was given in the number of *ENGINEERING* for July 13, 1866, the only difference being in the dimensions of the *Wolverine's* engines, which have four cylinders, each of 8½ in. diameter and 9 in. stroke. The engines run at 200 revolutions per minute. The screw propellers are of gun-metal, and are three-bladed; their diameter is 4 ft. 3 in.; pitch, 5 ft. 5 in.; and length, 6 in. The boiler is on the locomotive principle, and 8 ft. 6 in. long. The barrel of the boiler is 3 ft. 9 in. diameter, and contains fifty-four brass tubes 5 ft. 6 in. long, and 2½ in. diameter. The size of the firebox is 3 ft. 7 in. by 2 ft. 10 in., and the diameter of the chimney 14 in. These engines are capable of working up to 100 horse power. The total weight of engines, propellers, shafting, boiler, and water is only 7½ tons. The engines are very highly finished, and in consequence of their compact arrangement occupy very little room. When tried, the *Wolverine* was found to have attained a mean speed of about 13 miles per hour, which is a most remarkable result when the size of the yacht and the light draught of water, for the propellers, is taken into consideration.

RUSSIAN SLEEPING-CARRIAGE.

WE give, on page 366, engravings of a fine sleeping-carriage constructed for the Nicolai Railway (Russia) from the designs of Messrs. Winans. Our illustrations represent a part side elevation and part longitudinal section of the carriage, as well as a sectional plan, and these views will explain its arrangement very clearly. The main body of the carriage is rather more than 55 ft. long over all, and it is supplemented by an upper story 17 ft. 6 in. in length inside, situated over the two central compartments. The frame of the carriage is partly of wood and partly of iron, and the side frames or soles are strongly trussed, as shown in the side elevation. The carriage is carried on two four-wheeled bogies on the American plan, the centres of the bogie pins being 40 ft. 8 in. apart. The bogie wheels are 3 ft. in diameter, and the two axles of each bogie are 4 ft. 2 in. apart from centre to centre.

As will be seen from the sectional plan, the lower story of the body is divided into six compartments, five of these being of equal size and similar to each other, and the sixth being larger, and containing the staircase by which access is gained to the upper story. The upper story consists of one compartment only. The largest compartment in the lower story occupies a nearly central position, there being three of the smaller compartments between it and the one end of the

carriage, and two between it and the other end. The carriage is entered at the ends, where there are open platforms, and from these platforms passages, 2 ft. wide, lead to the various compartments, as shown in the sectional plan. The lower story of the carriage is 9 ft. 9 in. wide outside, and 8 ft. 1 in. high inside at the centre, except under the upper story, where the height is reduced to 6 ft. 3 in. The height of the upper story inside is 6 ft. 6 in., and the height of its top above the rail level is 17 ft.

The small compartments of the lower story are 7 ft. long, with a clear width inside of about 6 ft. 9 in. The seats in these compartments, when used as seats, are capable of accommodating three passengers each, making six passengers to each compartment; but when the seats are converted into beds, each compartment affords accommodation for four passengers only. The manner in which the seats are converted into beds is shown in the compartment at the right hand of the engraving. From this it will be seen that the back of each seat is hinged at the top, and can be turned up into a horizontal position. This having been done, the seat itself is also turned up, so that the legs, by which the front of it was supported, form brackets, which carry the now horizontal back. The arrangement can be readily traced out by comparing the two compartments on the right of the engraving, the seats in one of these compartments being shown down, and in the other converted into beds.

By turning up the seats in the manner we have described, two beds, raised considerably from the floor, can be formed in each of the smaller compartments, and two other beds can also be made up on the floor beneath the seats. The smaller compartments are shut off from the passages by sliding doors, and each is lighted by a single window only. There are, however, other windows in the passages, and these also furnish lights to the various compartments when the doors of the latter are open. At each end of the carriage a water-closet is provided, and the arrangements are throughout such as to provide for the comfort of the passengers.

When, as in Russia, a railway journey lasts sometimes four or five days, sleeping-carriages of some kind become almost a necessity, and the carriage we illustrate affords a good example of how this necessity may be provided for. In America too, sleeping-cars are becoming common for long journeys, and they are also used in France, whilst it is very probable that they will eventually be provided on some of the main lines in this country. A night trip from London to Scotland, although but a short journey when compared with the railway passages which may be made in Russia and America, is yet quite long enough to enable a passenger to appreciate the luxury of a well-fitted up sleeping-carriage, and we have no doubt that if such carriages were provided for a moderate extra charge, travellers would be found to readily avail themselves of them. In conclusion we should state that the engravings of the sleeping-carriage for the Nicolai Railway have been prepared from a very highly finished coloured drawing, with which we have been favoured by Mr. William Winans. The carriage was, we believe, constructed at the head works of the railway company at Alexandrofsky, near St. Petersburg.

TOOLS AND TOOL-HOLDERS.

THE expense of making and maintaining in order cutting tools forms a considerable item in the cost of working any engineering establishment, and, this being the case, it is important that such tools should be constructed in the most efficient and economical form. The ordinary diamond-pointed tool, formed out of a bar of square steel, is open to several objections. It is expensive to forge, especially if made in the hooked shape, as shown in Fig. 1 of the engravings on the next page, and its grinding to a correct form requires the expenditure of considerable time and attention. As the top surface of the cutting portion is ground away, moreover, the tool requires packing up under the stem to bring the cutting part in a line with the lathe centres; and the tool will not cut cylindrical and flat surfaces without its position in the slide-rest being changed. The diamond-pointed tool also produces a series of ridges and furrows, as shown in Fig. 18, when fed with a coarse feed over the work.

To avoid some of these inconveniences, rounded steel cutters, held by slide-rests specially formed for the purpose, have been used to some extent successfully for turning small rollers for cotton machinery, and triangular cutters have also been tried with partial success. The round cutters above mentioned are carried in rests which project under the roller which is being turned, and which are provided with a hole in which the cutter is placed. Owing to the small size of the rollers, the rests come nearly up to the level of the lathe centres, and the cutters thus project but little above them; in the case of heavy work, however, the projection of such cutters above the top of the rest would be considerable, and they would therefore spring, and be too unsteady to be practically useful.

To get over this difficulty, and to render the advantages which round cutters undoubtedly possess available for heavy work, Mr. W. Ford Smith, of Manchester, has designed the tools and tool-holders which form the subject of the present notice. According to Mr. Smith's plan, the cutting tool, which is distinct from the holder, is formed of a short piece of solid round steel ground to the proper angle and fixed at the proper inclination in the tool-holder, whilst the tool-holder, which is shown by Figs. 4 and 5, is of such a shape as to be applicable to all the principal descriptions of work. Six different sizes are made, to suit the different sizes and classes of work, and for machines varying from large to small sizes.

The cutters, A, A, are of the very best quality of steel, and are made from round bars cut into lengths with a cold set; each length is long enough to form two cutters, and is slotted through the centre while cold at the proper angle, as shown in Fig. 6, by a machine arranged for the purpose. The ends of a number of the cutters are then heated in a small furnace, and hardened in cold water. The tool-holders, B, B, are made of a strong and tough quality of steel, and, after being forged nearly to the required shape, are stamped while red-hot by a steam hammer in dies of the proper form. The upper and lower sides of the shank are planed parallel, to ensure its always bedding fairly and firmly in the tool-boxes of the machines in which

it is to be used; and the holder is then drilled for receiving the cutter, the hole being bored always at one standard angle, so as to give the correct angle of clearance to the cutter in every case, by means of a permanent inclined saddle upon the boring-table, in which the holder is fixed.

The cutter is held in the tool-holder by a steel set-screw, C, shown in Fig. 10, the end of the screw being recessed in the centre; and the portion of the cutter that it bears against is not hardened, so that the cutter is indented by the set-screw. The bite obtained by this means, together with the friction of the cutter in the tool-holder, is sufficient to allow of a heavy cut being taken without forcing the cutter back in the holder. In order to prevent the cutter from becoming jammed in its hole in the tool-holder by the slight burr raised upon it by the end of the set-screw, a clearance groove is slotted out down the side of the hole where the set-screw enters. The set-screw is placed square with the cutter, and at an angle of 80° from the face of the tool-holder, so as to keep it well clear of the work. If an unusually heavy cut has to be taken, a tool-holder is employed with a set-screw at the bottom, which is screwed up till it bears against the lower extremity of the cutter, as shown in Fig. 9.

In the construction of these tools the angle that is found best for the clearance parts of the tools, Figs. 2 and 3, is adhered to as a standard in all cases, both for cutting cylindrical, taper, or flat surfaces in lathes, and for surfacing, down-cutting, or angling in planing-machines; as any deviation from the best angle gives inferior results in cutting. Mr. Smith has found that an angle of 1 in 8 measured from the surface planed by the tool, as shown in Figs. 2 and 3, gives the best results. This inclination was accordingly adopted in the tool-holder first made, for cutting surfaces at right angles to the shank of the tool-holder, as shown in Fig. 3; and another holder was also made with the same angle of clearance on one of its sides, as shown in Fig. 2, instead of at the end, for cutting surfaces parallel to the side of the tool-holder. Both of these, however, were superseded by the improved tool-holder shown in Figs. 7 and 8, combining the two previous attempts in a single tool-holder adapted to both purposes, having the angle of clearance both at the end and also at the side of the holder. The cutter is placed at the corner of the holder, so that the ground surface of the cutter is not square with either the side or the end of the holder, but midway between these two positions, at an angle of 45°, as shown in Fig. 7. It will be seen from the comparative diagram, Fig. 16, that the form of the new cutter closely corresponds with the most approved form of the cutting part in the best ordinary tools, the only difference being that the round cutter is made separate from the holder instead of being forged solid in one piece with it.

In Fig. 7 is shown at D a plan of the tool-holder fixed on a slide-rest, with the tool in the act of turning the surface of a collar on a shaft, and thus cutting a flat surface. At E is shown the same holder still fixed in the same position on the slide-rest, but the tool is turning the cylindrical portion of the same shaft. The arrows show the direction of feed of the tool, at right angles to the shaft at D, and parallel with the shaft at E.

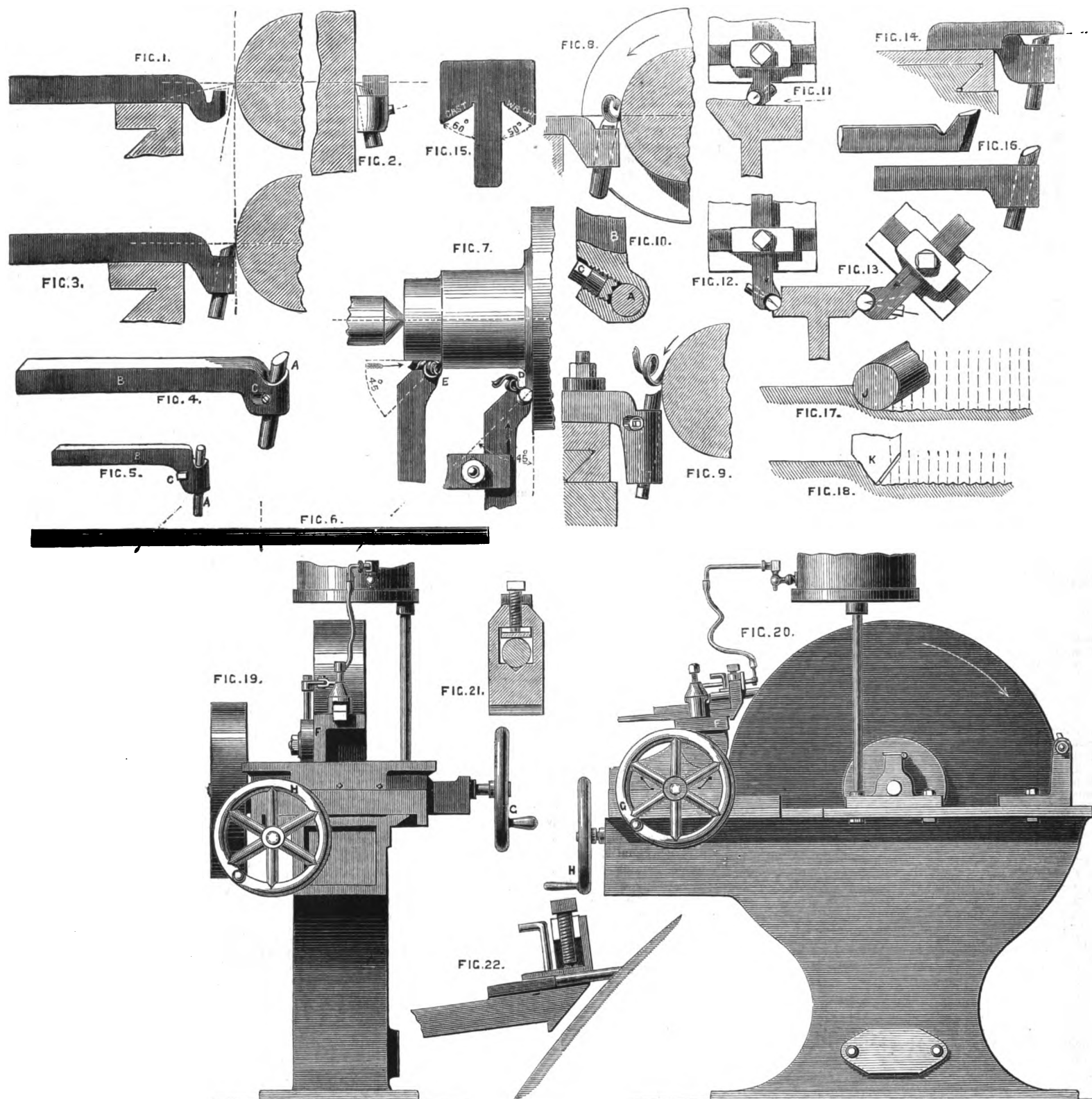
In turning cylindrical surfaces with the round cutting tools, it is of course requisite that the cutting point of the tool should be exactly on a level with the lathe centres, and for this purpose a sheet-iron gauge of the simple form shown in Fig. 14, is supplied to each lathe. As the tool is adjustable in the holder by the set-screw, it can be kept constantly at the proper height for cutting without the necessity for inserting any packing under the tool-holder. The tool-holders are made in pairs, right-handed and left-handed, as shown in Figs. 12 and 13. Fig. 11 shows one fixed in the tool-box of a planing-machine; Fig. 13 shows it planing down the flat vertical surface of the inside of a lathe bed; and Fig. 12 shows a left-handed tool-holder down-cutting the outer angle of a lathe bed.

It is very important that cutting tools should have the correct form given to them, and to avoid all risk of inaccuracy in grinding the round cutters are shaped by the use of the principle of mechanical grinding introduced by Mr. Whitworth. Figs. 19 to 22 show the grindstone designed for this purpose by Mr. Smith, the tools being held against the face of the stone in a slide-rest, F, adjusted at the correct inclination. The rest is traversed backwards and forwards by the hand-wheel, G, across the face of the stone during the grinding; and by the second hand-wheel, H, the tool is held up against the stone with the required pressure. By this means the grinding of the tools at the correct angle for cutting is always ensured. The two angles that Mr. Smith has found to answer best for the cutting edges of the tools are shown in Fig. 15, which represents one of the angle gauges that is employed for testing the accuracy of the tools. These two standard angles—50° for wrought iron, and 60° for cast iron and brass—are always adhered to for all the cutting tools; and the tools are tried by this gauge in grinding, the slide-rest being set at the required inclination to the face of the grindstone. At Mr. Smith's works in Manchester, where these tools are in general use, it is found that on an average fifteen of the round steel cutters are blunted in one day's work by each machine; and they take about a quarter of an hour for regrinding them, or an average of one minute each.

The maximum depth of cut which any of the round cutters will take is one-half its diameter; and the largest size of the round cutters being 1½ in. diameter, if a cut of more than ¾ in. depth is required, a cutter is employed made of an oval section of steel, 1½ in. deep by ¾ in. thick. This oval cutter is capable of taking a cut of 1 in. vertical depth in planing a horizontal surface; and in order that the cutter may not be forced back in the holder by the severe pressure of so deep a cut, the holder is in this case made with a solid bottom behind the cutter; as the cutter becomes worn down, a few blanks from a punching-machine are placed under its end to fill up the bottom of the socket in the holder.

The quality of the work produced by the round steel cutters is found to be much superior to that obtained with the ordinary diamond-pointed tools, under the same circumstances as regards depth of cut and amount of feed, the superiority of the round cutters in this respect arising from the difference of their action, as illustrated in the diagrams, Figs. 17 and 18. Since the smoothness of the finished surface increases in proportion as the thickness of the shaving diminishes, the diamond-pointed tool in taking a heavy cut leaves the surface as rough at the

TOOLS AND TOOL-HOLDERS, AS DESIGNED AND CONSTRUCTED BY MESSRS. SMITH AND COVENTRY, ENGINEERS, MANCHESTER.



bottom of the cut as at the top, since the shaving removed is of uniform thickness through its entire depth, as shown by the shaded portion, K, in Fig. 18. But with the round cutter the shaving is only thick at the top, as shown by the shaded portion, J, in Fig. 17, and the thickness gradually tapers away to almost nothing at the bottom, where the shaving becomes nearly a tangent to the circular cutting edge of the tool.

When Mr. Smith read a paper—to which we are indebted for the facts contained in the present notice—on these tools and tool-holders before a meeting of the Institution of Mechanical Engineers in November last year, the difference in the quality of the work produced by the round cutter as compared with the diamond-pointed tool was shown by a specimen of work exhibited to the meeting. An ordinary diamond-pointed tool with a slightly rounded point was first started, and allowed to plane a width of $\frac{1}{4}$ in. over the surface of the wrought-iron plate exhibited. One of the round cutters, $\frac{1}{4}$ in. diameter, was then started to plane where the first left off, and after planing about 1 in. width was stopped in the middle of a cut. The feed was exactly the same in both cases, and the tools cut dry, without soap and water. The round cutter left a very fair finish for a rough dry cut, which contrasted favourably with the finish left by the ordinary

diamond-pointed tool; the minute ridges also left between the successive cuts of the round tool were hardly perceptible, being only about one-fifth of the height of the ridges left by the ordinary tool, as shown in the diagrams, Figs. 17 and 18.

This experiment served also to determine approximately the amount of power required to drive the round cutters, which is stated to be only about three-fourths of that necessary to drive the ordinary tools for doing the same work. The ordinary diamond-pointed tool employed in the experiment was shaped to the most approved form for cutting wrought iron; and the depth of cut being $\frac{1}{16}$ ths in. with a feed of 24 per inch, it was found that a weight of 74 lb. was required, pulling direct upon the driving-strap, to enable the tool to take the cut. After planing the width of $\frac{1}{4}$ in., the round cutter, $\frac{1}{4}$ in. diameter, was substituted, going on from where the other had left off, and working under precisely the same circumstances; and the weight required upon the strap was only 56 lb., or about three-fourths of that required with the ordinary tool.

With regard to the saving effected in current expenses by the use of the improved tool-holders and round cutters, it has been found at Mr. Smith's works that one smith and striker who had been almost wholly employed in repairing and making the

ordinary solid forged tools are now dispensed with; and instead of two grindstones being always fully occupied in grinding the tools, the whole grinding of the cutters is now done by a single stone, requiring only one man to attend to it. We believe that these compound tools and tool-holders are destined to come into extensive use.

LARGE RAILWAY CONTRACT IN AMERICA.—It is stated that Honourable Oakes Ames, of this State, has contracted to build nearly the whole of the remaining portion of the Union Pacific Railway—some 6000 miles, passing through the Rocky Mountain region—receiving therefor over \$17,000,000. This is believed to be the largest single contract ever entered into by one man. Mr. Ames, though a large railway-owner, has never been known as personally interested in railway construction, and is therefore somewhat new to the business. He is, however, from his high character, remarkable business ability, great success, and large means, well adapted to lead in this great enterprise; and if any one can make a success of it, he is just the man. We have since learned that he has associated with him several large capitalists, uniting great wealth and plenty of railway experience.—*American Railway Times.*

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Office for Publication and Advertisements, No. 37, Bedford-street, Strand, W.C.

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ENGINEERING.

FRIDAY, OCTOBER 18, 1867.

IMPERFECT RAILWAYS.

QUITE one-half of the average resistances to traction on level railways is known to be due to imperfections in the condition of the permanent way. If all railways were level one-half only of the present locomotive power would be required, and one-half only of the present working expenses incurred upon a perfect as compared with an imperfect way. The case is altered upon gradients, as they oppose the full additional resistance due to gravity in going up, and with the single exception of a saving in fuel, they return nothing in coming down. If, as is almost certain to be the case, the working speed is greater in coming down than in going up, the wear and tear are also greater, and upon long gradients in a double line the rails in the descending line are found to be more worn than those in the ascending line. We should say "down" and "up" lines, except that these terms have an arbitrary and unnatural sense as expressing the direction of the traffic to or from London.

Upon a perfect railway, formed of mathematical planes, and having mathematically cylindrical wheels rolling upon them, the tractive resistance would be constant at all speeds, and it would not exceed 5 lb. or 6 lb. per ton, and it would be quite practicable to run trains at 150 to 200 miles an hour with engines of the present weight and power. The constancy of the resistance with varying speeds was shown, a century ago, by the French experimenters, Vince and Coulomb, and it was again proved by George Stephenson and Richard Roberts, and this, at one time, in the face of much doubt on the part of eminent English engineers. Had we such things as perfect railways, we fear, indeed, that our present gradients would not be tolerated. A gradient of 1 in 100 adds 22.4 lb. to the other resistances of the train. If these are already 22.4 lb. per ton, the total resistance is doubled; but if, upon a perfect railway, they were but 6 lb. per ton, it would require an engine of nearly five times the strength to work up 1 in 100 that would be required upon a level. On an inferior horse roadway, the resistance upon a level is doubled only upon gradients of from 1 in 30 to 1 in 40, and the makers of traction engines consider even 1 in 12 to 1 in 16 very fair ascents.

In speaking of "perfect railways," lines are to be understood whose surface and gauge are as even as those of Mr. Whitworth's true planes and cylinders, for absolute microscopic accuracy is much further than need be considered.

George Stephenson believed that he could make his railways "perfect." Indeed he told Mr. Alderson so, during his examination by that barrister, upon the Liverpool and Manchester bill in 1825. He said that

any railway that would bear a train at four miles an hour would bear it also at twelve. "Is not that," he was asked, "upon the hypothesis that the railroad is perfect?" "It is; and I mean to make it perfect." It was this strong faith in the near constancy of the resistances at all speeds, and in the perfectability of the permanent way, that made George Stephenson, all his life, so strong an advocate of very flat gradients. He had not contemplated such high tractive resistances as are presented in ordinary working now-a-days, resistances so high that they are only doubled upon gradients of from 1 in 100 to 1 in 120. His idea was that the tractive resistances should be so light that they would be doubled upon gradients of even 1 in 250 or 1 in 300, and it is but just to own that his ideas of the mechanical capabilities of railways were more philosophical than the rough and ready and "anything will do" notions into which we have subsided, and which enable us to look upon even 1 in 40 with perfect complaisance, and which have rather made engineers ambitious to see how steep rather than how flat gradients they can lay out and work successfully.

It would be an experiment of great national value if, say, even a mile of approximately perfect way could be put down on a level portion of some existing line, and careful tests of the resistances "on" and "off" the mile made and reported. It would be necessary to work the trains at the same uniform speed over this mile as on the adjoining portions, and this could be done by a careful driver having a chrono-counter connected with the driving wheels of his engine, or one of Mr. Ramsbottom's beautiful speed-indicators. We will not say what a mile of such line would be in structure, but it would, if "perfect," be truly straight (or truly curved, where curves could not be avoided), truly planed, and of exactly uniform gauge, and, what is exactly important, exactly uniform strength. We will not say how the essential element of slight elasticity would be secured, but there are many ways.

It is certain that only steel rails, steel fished, would afford the necessary hardness, smoothness, and uniformity of strength for a "perfect railway." At present iron rails deflect sensibly under the wheels, say $\frac{1}{8}$ th in. between 3 ft. bearings under a 6 ton wheel, corresponding to a gradient of 1 in 360 from the mid span up to each chair; and as the ascent is not in a straight line, but follows a parabolic curve, the real tangent to this curve next the sleeper is inclined 1 in 180, and the wheels must take this upward direction perhaps twenty or even thirty times a second to fall with increased force just as often upon the succeeding spans between the sleepers. If a single sleeper fails in its bearing, the deflection is much increased. There is plenty of time, even at the highest speeds, for the effect of gravity. A body will fall $\frac{1}{8}$ th in. in the $\frac{1}{4}$ th part of a second, and $\frac{1}{2}$ in. in the $\frac{1}{2}$ nd part, which is more than equal to the time occupied, at forty miles an hour, in passing over 18 in. of rail, or the half span between two sleepers. The often quoted analogy of skating quickly over thin ice does not apply here, as the water under the ice has to be displaced, before it can yield, and this takes time. Steel rails of the same section as iron rails deflect hardly more than one-half as much under the same load, and may therefore be expected to greatly lessen the resistances at high speeds.

THE GLASGOW UNIVERSITY.

THERE is in this great country of engineers but one authorised and acknowledged high school of engineering science, and that is the University of Glasgow. In making this statement, we do not overlook the different courses of lectures on engineering subjects which are occasionally delivered at other public colleges or universities, and for an example of which we may at once refer to the advertising columns of this paper, where there is announced the series of lectures to be held by Professor Fleeming Jenkin, at the London University College. These series of lectures, however valuable and interesting their teachings may be, do not pretend to afford anything like a complete scientific or professional education, while the teachings of the engineering professors of the Glasgow University give, or profess to give, a complete training and professional education in the theory of engineering science, just as much as the other professors of the same university complete the professional education of the students in their respective branches. In this respect, the engineering faculty of the Glasgow University is nominally placed upon the same level as the engineering colleges of France or Germany, say with the Ecole Centrale, of Paris, or the Polytechnic School of Carlsruhe, Zurich, or Hanover.

The Glasgow University is just now in a state of transition, which is likely to make a new era in the

history of the establishment. The old building occupied by this seat of learning is about to be destroyed, and replaced by a railway-station, and another building, much better adapted to the purposes for which it is required, will be shortly erected upon a suitable site. Funds have been provided with the usual liberality which characterises "self-made" men in this country, who appreciate the benefits of a suitable education from feeling the want of it. This, with a further assistance to be given by Government, holds out a good prospect of the new University of Glasgow becoming a model establishment, and one to which engineers in particular will have to look as a standard for imitation in other parts of this country. While entertaining and expressing such a hope, we cannot deny that the Glasgow University, or, at least, its engineering section, will require some considerable reform before it can come up to the justifiable demands of the profession and of the public of the present day. In its present state its arrangements are incomplete, and, therefore, necessarily defective. If the fame and celebrity of professors could do it, the names of Sir William Thompson and of Professor William John Macquorn Rankine would certainly be more than sufficient to establish its position; but we are sorry to say that the majority of engineering students in Glasgow do not frequent the lectures of the former, and do not understand those of the latter. This, as Professor Rankine very often remarks with regard to his books, which are said to be above the capability of the professional public, is not the fault of the professor, but of the public; but it is in so far a fault of the Glasgow University that the training in mathematics, which must of necessity precede the study of applied mechanics, is not sufficiently extended to enable the students to follow the learned demonstrations of Professor Rankine. It can therefore surprise nobody that Professor Rankine, whose works are amongst the most popular in Germany, and are preferred by German students to the books of many of their own professors on account of the decidedly practical tendency which prevails in them, finds it so extremely difficult to give to his own pupils that same amount of information for which the engineers of other countries are indebted to him, and which is acknowledged by the great celebrity of the professor's name in the scientific world. Supposing, however, that a student should have followed the lectures of natural philosophy and of mathematics, and should have ultimately understood the lectures in the civil engineering class of Professor Rankine, all this would not even then complete his theoretical education as a modern engineer. The Continental nations have converted the art of linear drawing into a science, called descriptive geometry. This science reduces the entire practice of engineering drawing, perspective, and other representations of figures by space, to an exact and complete system, generalising the laws and rules, and making their application in practice more a question of knowledge than of skill. There is, moreover, such a science as practical geometry, which everywhere, except in England, forms part of the education of a civil engineer. This, in unscientific hands, is reduced to the craft or practice of surveying and levelling. We need not explain now how useful such knowledge is to the practical engineer, and how quick it can be learned, if systematically brought before the student, while the usual form of apprenticeship in this department is extremely slow, and almost in all cases incomplete, from want of variation. There are, besides these, lectures on chemistry, mineralogy, and botany delivered at every engineering college on the Continent. These, of course, the Glasgow University has as well; but there they are not considered to form an essential part of engineering education, and are generally neglected by the students in that branch. When M. Messmer, the present manager of the Graffenstaden Works, in France, commenced his lectures on mechanics at the celebrated school at Carlsruhe, in which he was the first professor of mechanical science, he combined with his lecture-room a workshop for his students. This workshop served no commercial purpose, and nothing produced in it was ever sold. The students were employed there in applying practically what they had learned before in a more abstract form. The problem may have been to produce an inch cube or something similar, and all the refinement of scientific knowledge would have been brought to bear upon this one feat, each student of course being employed in making his own cubic inch, and being therefore obliged to go through all the processes himself. To any one at all acquainted with the amount of work and attention it requires to produce a correct cubic inch of iron, or brass, or wood, or whichever material may have been

chosen by the student, it will be obvious at once what an amount of precise and practical knowledge a scientifically trained young man must have accumulated by the time he had completed a tolerably accurate cubic inch, or a cylinder of a given size, or any other similar object. The workshop of the mechanical class at Carlsruhe remained in existence under M. Messmer's successor, Professor Redtenbacher, and it has been imitated in many other first-class engineering colleges on the Continent. Those schools which cannot afford to maintain workshops of their own send their students to the existing factories in the neighbourhood in order to make sketches, observations, and reports, which are afterwards critically examined by the professors.

The Ecole des Ponts et Chaussées at Paris, the most celebrated civil engineering school in the world, divides its courses into lectures and practical exercises. The students are, for this latter purpose, distributed in groups throughout the public buildings and works in course of execution at Paris and elsewhere in France. There they are engaged—with more advantage to themselves than to the engineers in charge of the works—in nominally assisting, but virtually studying the practice for which they are preparing, and, after each such campaign, they return to their college in order to present there the results of their observations and industry in the form of notes, sketches, and complete drawings. At Zurich, Hanover, and at Vienna the private manufacturers afford similar facilities to the students of mechanics in their own works, and experience has proved that such a practice once properly organised does not cause any sensible disturbance in the works, and is attended by no difficulties of any kind.

There is no more suitable place for successfully imitating the last-named arrangement than the town and neighbourhood of Glasgow. The town itself, and the trustees of the Clyde, have almost incessant work before them, and under execution in the different public buildings, docks, and other works to be made and kept in repair. Two important railways have their central workshops in Glasgow, and the number of ship-building yards and engineering establishments is equalled by few localities of the same area. Blast furnaces and ironworks—although instructive principally through their deficiencies in scientific arrangement—are close at hand, and a vast number of chemical works can supply practical illustrations to the theoretical teaching of the college. There can be no doubt that the engineers and manufacturers of Glasgow, the men who have contributed at the rate of thousands of pounds each to the funds of the university, will gladly open the doors of their works to the students of its engineering division, if they are once brought to understand the question. The reorganisation, however, and introduction of a system of training which will include so complete and thorough an engineering education will rest with the University itself. That such education is at present wanted in this country there can be no doubt; that it is practicable is shown by the example of the Continent; and that it is beneficial has been proved with sufficient tangibility by the present Paris Exhibition. Let us hope, therefore, that the new University buildings of Glasgow will not be merely a new house for an old-fashioned and unsuitable institute, but that the new structure will form a modern engineering college equal, if not superior, to the best professional school in existence elsewhere.

RAILWAY ECONOMY.

MR. SMILES, in his admirable *Life of George Stephenson*, tells us how slow were the directors of the Stockton and Darlington line to be convinced of the superior economy of wrought-iron as compared with cast-iron rails. Stephenson had a patent for a cast-iron rail. "But when requested to give his opinion on the subject, he frankly said to the directors, 'Well, gentlemen, to tell you the truth, although it would put 500*l.* in my pocket to specify my own patent rails, I cannot do so after the experience I have had. If you take my advice, you will not lay down a single cast-iron rail.' 'Why?' asked the directors. 'Because they will not stand the weight; there is no wear in them, and you will be at no end of expense for repairs and re-lays.' 'What kind of road, then,' he was asked, 'would you recommend?' 'Malleable rails, certainly,' said he, 'and I can recommend them with the more confidence from the fact that at Killingworth we have had some Swedish bars laid down—nailed to wooden sleepers—for a period of fourteen years, the wagons passing over them daily; and there they are, in use yet, whereas the cast rails are constantly giving way.'

"The price of malleable iron was, however, so high—being then worth about 12*l.* per ton—as compared with cast-iron rails at about 5*l.* 10*s.*, and the saving of expense was so important a consideration with the subscribers to the railway, that Mr. Stephenson was directed to provide, in the specification drawn by him, that only one-half of the quantity of the rails required, or 800 tons, should be of malleable iron, the remainder being of cast iron. Malleable rails were required by the specification to be made from scraps, or good English bars, remanufactured. They were also at the time called fish-bellied, after Birkenshaw's patent, and weighed only 28 lb. to the yard, being 2½ in. broad at the top, with the upper flange ¾ in. thick; they were only 2 in. in depth at the points at which they rested on the chairs, and 3¼ in. in the middle or bellied part." Steel has very nearly as great advantages over wrought iron as the latter has over cast iron. Yet the directors of our modern railways are slow to adopt it for the reason which so influenced the Stockton and Darlington directors, for steel rails are now, as malleable iron was then, worth 12*l.* per ton (taking the lowest quotations), and wrought-iron rails are now, as cast iron was then, worth 5*l.* 10*s.* per ton. What ingenious evidence might have been then brought up against the use of wrought iron, based upon calculations of its greater compound interest! Like the engineer of one of our great metropolitan lines (or which will be one when a certain great metropolitan station, now in progress, is once open for traffic), the directors might have said, "If you can prove that wrought-iron rails will last for ever, I would not use them, for I can buy cast iron, and renew it every ten years, for less money than they would cost, taking one hundred years with another." Then it might have been argued that whereas old cast rails could be popped into the cupola, and converted into valuable castings, old wrought-iron rails would have no value, that they would not, indeed, be worth carting away from the railway when taken up. We don't know whether even Stephenson pointed out that wrought-iron rails need not really cost more than cast-iron rails, albeit that the price was more than twice as great per ton. For we do not suppose that his patent cast-iron rails were made to weigh but 28 lb. per ton. More likely they weighed 56 lb. or 60 lb., and were even then weaker than wrought iron.

Rails are, after all, only girders—short iron bridges of 3 ft. span—and we know that, in bridge work, cast iron, although of but one-third the price of wrought iron, has but one-third the strength, and that for spans where the weight of the bridge bears a considerable proportion to the load cast iron is wholly inadmissible.

With respect to steel, we are delaying, in these slow times, to avail ourselves of a means of economy hardly less than that due to the substitution of wrought for cast iron rails. Engineers and railway managers are showing an almost culpable apathy upon this vast question, and it will in this, as in so many other previous cases, be flung in our faces that it takes us, as a nation, ten years to even *understand* a great invention of attested success.

It is at least time that the absurd doctrine that steel costs more, for a given strength and service, than iron was exploded. A ton of steel, of course, costs more than a ton of iron, but, for equal strength, a 56 lb. steel rail is at least as strong as an 84 lb. iron rail, and it will wear more than twice as long, the wear depending upon hardness, irrespective of mere strength to support a rolling load. Engineers, having adopted a certain section for iron, specify the same for steel, and so far they do well; but they give the steel no credit for its far greater strength, and, because they thus obtain this at the expense of weight, speak of steel, as the Stockton directors did of wrought iron, as if it were the more costly material. Steel can, of course, be made of any quality, hard or (comparatively) soft, according to the proportion of carbon given it, and which is entirely under control. The very hard rails may occasionally break, and should never be accepted nor made; but with ½ per cent. of carbon a very durable and at the same tough rail is insured. With this proportion, adopted by Mr. George Berkeley for the 22,000 tons of steel rails made to his order for the Great Indian Peninsula Railway, a double-headed 86 lb. rail, supported on 3 ft. 7½ in. bearings, took no permanent set under a load, applied at the mid-span, of 20 tons, the temporary deflection being but 0.11 in., a test which would have destroyed an iron rail. Not merely in respect of deflection, but in that of strength to resist impact, the steel rail is enormously stronger than iron, bearing without breaking the fall of a one-ton ram, falling from 25 ft. to 40 ft., the rail being supported upon 3 ft. bearings. For equal strength to iron, steel rails are now made of far greater section and

weight than are required. They thus make a smoother and better road, as well as a more durable road, and the increased weight and cost thus incurred is not to be set down as against steel compared with iron for a given strength.

FUEL FOR INDIAN RAILWAYS.

AT page 328 of *ENGINEERING*, for October 4th last, it was pointed out, from information derived from the very highest authorities, that, viewed as a coal-producing country, India could not be considered as either largely or widely supplied with this essential source of motive power; and the narrow band of bituminiferous rocks which occur, almost in a direct line, from Calcutta to Bombay, are at such a distance from many of the railway lines as to preclude the use by them of the produce of those districts, on account of the great cost that must necessarily be incurred for land carriage, and the high price which such fuel would consequently be raised to by the time of its arrival at the railway depôts, more particularly those in Madras or in the Punjab. But even where it is used for locomotive purposes, the Indian coal, on account of its inferior character and the large amount of ash which it produces, proves in practice but little cheaper than coal sent out from England. Under such circumstances the fuel employed on several of the lines is mostly wood obtained from the forests in the country; and until further inventions or discoveries place at our disposal some other means of producing motive power, or some more economical method of generating steam through the agency of heat, wood fuel must continue to form the principal source upon which the Indian railway locomotives must rely; and, that being the case, it behoves the several companies interested, and more particularly the Government (as we shall presently show), to see that proper supplies of this or other fuel are kept constantly in store at stations along the different lines of railway, and, further, that due regard be paid to the proper conservancy of the forests whence this fuel is obtained.

At present the railway companies have not any plantations set apart for their exclusive use, and they are consequently dependent upon supplies brought in to them by the native woodcutters, with whom, as a rule, they contract for certain supplies to be delivered at specified intervals of time. Now, knowing as we do the wonderful powers of combinations and secret communications possessed by these native castes, let us consider for a moment what would be the position, in the event of a second native rebellion, first, of the railways with reference to their supplies of fuel, and, secondly, of the Government with regard to the means of communication at their disposal for the movement of troops.

To avoid against the consequences of any combination amongst the woodcutters gradually to deprive the railway companies of their proper supplies of fuel, it should be a standing rule amongst them all that not less than sufficient for six months' ordinary use should always be kept in stock, and that not in a few large stacks, which would be liable to destruction from incendiaryism, but scattered in small quantities deposited at every station along the line. The necessity for this, in the interests of the companies themselves, will at once be apparent upon the following considerations: The native mind is keen enough to perceive that the ready means of communication afforded to the Government for the rapid conveyance of troops is equivalent to the possession of so many more European regiments for the purposes of holding the empire against revolt or revolution; to destroy a bridge, or to break up a few miles of rails, is but to cause a temporary obstruction, which, in either case, would be sure to be speedily repaired; but to deprive the locomotives of fuel would be a most sure and effectual method of putting a stop to the entire use of the railway, and would cause an obstruction to locomotion far less easily encountered and removed than in either of the former cases, and the only practicable preventive against the possibility of any such occurrence would be, as we have above stated, for the companies to retain in their possession always a minimum amount of fuel equivalent to six months' ordinary consumption. It is quite time, too, that this matter should engage the serious attention of the Government. The facilities enjoyed by the use of the railways for the movement of troops cannot fail, to a certain extent, to leave its mark on the military organisation of the country, by rendering the regiments less prepared than formerly to undertake rapid marches on a short notice; for the luxury of the present day, engendered by railways, must have its effect upon all down to the very drummer-boy of a regiment. To avoid, then, the certain paralysis which would seize the commander-in-chief and all below him, in the event

of internal disturbances in India, and a simultaneous stoppage of many of the railways for want of fuel, it is time that legislative enactment took the initiative with a view to rendering nugatory any combination of the native fuel contractors, which might otherwise lead to such disastrous circumstances. To be forewarned is to be forearmed, and we should look with very lively suspicion upon the first show of any apparent combination amongst the woodcutters to fail in their usual supplies. The events which preceded the former mutiny can now be traced and recognised as sufficient to have, at least, aroused suspicion, and we may rest assured that the first signs of any future similar trouble—should it ever be attempted—will be found to be some subtle devices aimed at the destruction or temporary crippling of our great railway systems, which may now be regarded as the greatest power in the hands of the Government for the rule and civilisation of the country.

LITERATURE.

A Treatise on the Strength of Materials by PETER BARLOW, F.R.S. A new edition, revised by his Sons, P. W. BARLOW, F.R.S., and W. H. BARLOW, F.R.S. Edited by W. HUMBER. London: Lockwood and Co.

THE review of a book in its sixth edition must always appear a work of supererogation, but doubly so when a standard work, as the above, commenced precisely half a century ago, and successively extended to keep pace with the progress of investigation, is the one to be criticised.

The present edition offers some important advantages over previous ones. The additions are both extensive and valuable, comprising experiments by Hodgkinson on the strength of cast iron; extracts from papers on the transverse strength of beams, by W. H. Barlow; an article on the strength of columns; experiments by Fairbairn, on iron and steel plates, on the behaviour of girders subjected to the vibration of a changing load, and on various cast and wrought-iron beams; experiments by Kirkaldy, on wrought-iron and steel bars; and a short appendix of formulæ for ready application in computing the strains on bridges. To make room for all these valuable articles without increasing the bulk of the volume, the description of the proving-machine at Woolwich Dockyard, and the article on the comparative strengths of parallel rails of different sections, have been omitted, and we think the scissors might have been advantageously used with still greater freedom.

Doubtless much of the early matter must appear antique and fantastic in the glare of light thrown on the respective subjects by modern investigation; yet a certain historical interest must always attach to these primitive attempts at the solution of problems of such great practical moment. As a case in point, we may instance the several tables given for determining the conditions of simple suspension bridges. Of course no one would now think of referring to a table, or indeed of employing more figures than would cover a postage-stamp, for the solution of such an elementary problem as the determination of the stress on a suspension chain. Such tables may be looked upon as the characteristic fossils of the period when engineering literature was almost entirely dependent upon the extraneous aid afforded by mathematicians, talented, beyond doubt, but lacking the hard practical method considered indispensable in any new contribution to the science of engineering.

It may be justly urged, on the other hand, that not only is it ungracious to criticise the labours of the early masters of the profession, but that in these days of concise formulæ and short treatises, when so much is given without demonstration, the perusal of articles such as those in the present work on the mechanism of transverse strain, the mechanical action of fibres, and the laws of deflexion, is a most wholesome incentive to independent investigation. Upon these early investigations are based the majority of the practical rules for the strengths of columns and beams, given in English and foreign pocket-books.

We may observe that many additional plates, referring to the new matter introduced, are appended to this edition.

Examples of Bridges and Viaducts. With the addition of upwards of 500 Estimates, and the Practice of Setting out Works. By W. DAVIS HASKOLL. Second Edition. London: Lockwood and Co. 1867.

THE work now before us is one of the very few extant descending to the level of ordinary routine, and treating on the common every-day practice of the rail-

way engineer. Usually, when a practical engineering book is written, it is with the view of elucidating some more difficult problem than is ordinarily met with, or some *spécialité* in the design of the works. Thus, a student of engineering would not find the least difficulty in familiarising himself with the complicated detail of skew arches, whilst he might search in vain for any written information concerning the ordinary methods of working the bricks so as to obtain "keys" as often as possible, in order to bond together the several rings of an ordinary brick arch or tunnel. Of course the knowledge of such details should be acquired during the period of pupillage, and yet comparatively few young engineers have this necessity impressed upon them, or indeed the opportunity given them of so doing; and on that account a work of the present nature, by a man of Mr. Haskoll's experience, must prove invaluable to hundreds.

Every engineer or contractor of experience will admit that thousands of pounds are thrown away on account of the pulling down and cutting away, incidental to careless and incorrect setting out; and since, as our author urges, comparatively few engineers are ever likely to be called upon to design long-span iron bridges, they should rather aim at perfecting themselves in the duties they may be called upon to perform any day; and that such an opinion is held by engineers generally is satisfactorily evidenced by the demand for a second edition of the present work.

As detailed estimates of proposed lines are now required by the Standing Orders, the tables of estimates appended to the present edition will considerably enhance its value.

In the portion devoted to the consideration of the design, setting out, and building of bridges, attention is drawn to the two extreme cases, between which all designs must range. In one system a large mass of material is thrown into the work; in the other the arrangement and distribution of the material is more carefully studied, so as to diminish the quantity of material used; in other words, the question is one of materials *versus* labour. It will be evident that even on the same line of railway the character of the works should vary with the locality; thus, on works such as Mr. Fowler's Metropolitan, economy of material is carried to the utmost, and concrete walls, with brick facings and counterparts, form the type of construction.

In many instances the contractor or his agent alone could determine the most economical mode of carrying out the works, since he may have material on the spot which, although intrinsically of greater value than is absolutely required, may be advantageously employed under the special conditions of the case. Thus, piles of a certain size may be required for the foundations of stonework, and timber of larger scantling, which had previously been used in timbering the excavations, may be on the spot; now the conditions of the individual case alone could determine the question whether it would be preferable or not to sacrifice the superfluous quantity of timber. Much, however, rests with the engineer, and the tables given in Mr. Haskoll's work of the quantity of lime required in mortar and concrete, and the number of bricks laid per day by one man in various portions of a structure, will prove very valuable as affording reliable data upon which he can base his calculations.

The importance of the most complete knowledge attainable of the strata through which a line passes has been so painfully impressed upon contractors by the ruin of their predecessors from the neglect of such precautions, that it is remarkable their attention should still require to be directed to such considerations. Mr. Haskoll has done well in enlarging upon this point.

Useful tables for constants for setting out skew bridges, and for finding the quantities of materials from the previous estimates for square bridges of similar span, are given in this edition. The drawings are explicit in detail, and give all the information necessary for the design of brick or masonry bridges or viaducts up to 100 ft. span. Many examples are also given of wrought and cast iron bridges and timber viaducts.

Long-span Railway Bridges. London: Spon. 1867.

THE majority of our readers will doubtless have made themselves familiar with this work, in its original form, as it appeared in the columns of our journal.

As the whole has been carefully revised by the author, and additional matter introduced, the work will, in its present form, attain its aim of presenting, in a simple form, a complete generalisation of the many complex questions governing the economical design of a long-span railway bridge.

RECENT PATENTS.

THE following specifications of completed patents are all dated within the year 1867; and that year should be given in ordering them, at the annexed prices, from the Great Seal Patent Office, Chancery Lane.

(No. 292, 1s.) Alfred Vincent Newton, of 66, Chancery-lane, patents, as the agent of Eli Thayer, of Worcester, U.S., Sabine Peters Pond, of Providence, U.S., and Daniel Bullard Pond, of Woonsocket, U.S., a form of water-tube steam boiler. This boiler consists of a number of horizontal water-tubes closed at one end, each tube containing another tube of smaller diameter open at both ends. The outer tubes communicate at their open ends with an upright tube leading to a steam dome, whilst the outer ends of the inner tubes are in communication with a water-space.

(No. 294, 10d.) William Richardson, of Darlington, patents a method of arranging the glazed frames of horticultural buildings, so that, when opened, they shall still form a protection against direct downward draughts, and prevent the entrance of rain. To accomplish this the opening sashes are each mounted on a series of links or arms, so that, when opened or raised, they move parallel to their original position, like the bar of a parallel ruler, and thus still cover the openings over which they are placed.

(No. 296, 1s.) Edward Smith Crease, of Plymouth, patents improvements in the rock-boring machines patented by him in October, 1863, these improvements referring to details which could not be described without reference to drawings.

(No. 299, 1s. 4d.) Robert David Napier, of 20, Church-row, Limehouse, patents various arrangements of differential brakes, and methods of applying these as substitutes for ratchet and pawl movements in windlasses and other machinery. In one form of these brakes the band or strap passing round the brake-wheel is connected at each end with a lever vibrating on a fulcrum situated between, but not equidistant from, the two points of attachment of the strap. The arrangement is such that when the wheel is turned in one direction, the friction between it and the strap tightens the latter, and *vice versa*. A number of models, showing various applications of these brakes, were exhibited by Mr. Napier at the conversazione of the Institution of Civil Engineers in May last.

(No. 300, 1s. 4d.) David Greig, Robert Burton, and Frederick Parker, of the Steam Plough Works, Leeds, patent several improvements of considerable value in connexion with steam ploughing-engines and machinery. These improvements include arranging the winding drum of a steam ploughing-engine under the smoke-box end of the boiler behind the hinder wheels; connecting the fly-wheel to its shaft by a friction clutch, so that, in case of an implement being checked, the fly-wheel may revolve free of its shaft without throwing too great a strain upon the rope; providing means for turning the implements by the movement of the traction-engine after the implement has been drawn up to the engine on the completion of its bout; and also a method of constructing the steering-frame and connecting the implements to it by vertical pivots, so that they may readily follow the frame.

(No. 314, 10d.) Joseph John Harrison, of 2, Ada terrace, Great Clowes-street, Broughton, Manchester, patents improvements in pneumatic looms, these consisting in arrangements for compressing the air by which the shuttle is driven.

(No. 317, 1s.) Percival Moses Parsons, of Blackheath, patents a method of constructing railway crossings by housing the side rail under the flange of the point rail, instead of notching it into it in the usual way. The point and side rail are bolted together, the bolts passing through blocks placed between the rails. The patent also includes making bolts with the shank part tubular or of a different section to the screwed portion, the object being to reduce the sectional area of the shank so that it may be the same as that of the screwed part at the bottom of the thread, the outside dimensions of the shank being at the same time such that it fills the hole.

(No. 334, 1s. 10d.) Stephen Alley, of the firm of Messrs. Neilson Brothers, of Glasgow, patents several useful forms of machine tools specially applicable for finishing various details of locomotive engines. We shall probably give illustrations of some of these tools in an early number, and shall therefore postpone any description of them for the present.

THE ROLLING-MILL AT ESSEN.—In Mr. Krupp's tyre-rolling mill at Essen, all the heating furnaces are situated below the floor level, the tyres being lifted out through openings in the roofs of the furnaces closed by sliding doors. The arrangement has the advantage of leaving the floor of the mill quite clear.

DOUBLE-ACTING STEAM-HAMMER WITH SELF-ACTING VALVE-GEAR.

CONSTRUCTED BY MESSRS. TANNETT, WALKER AND CO., ENGINEERS, LEEDS.

FIG. 1.

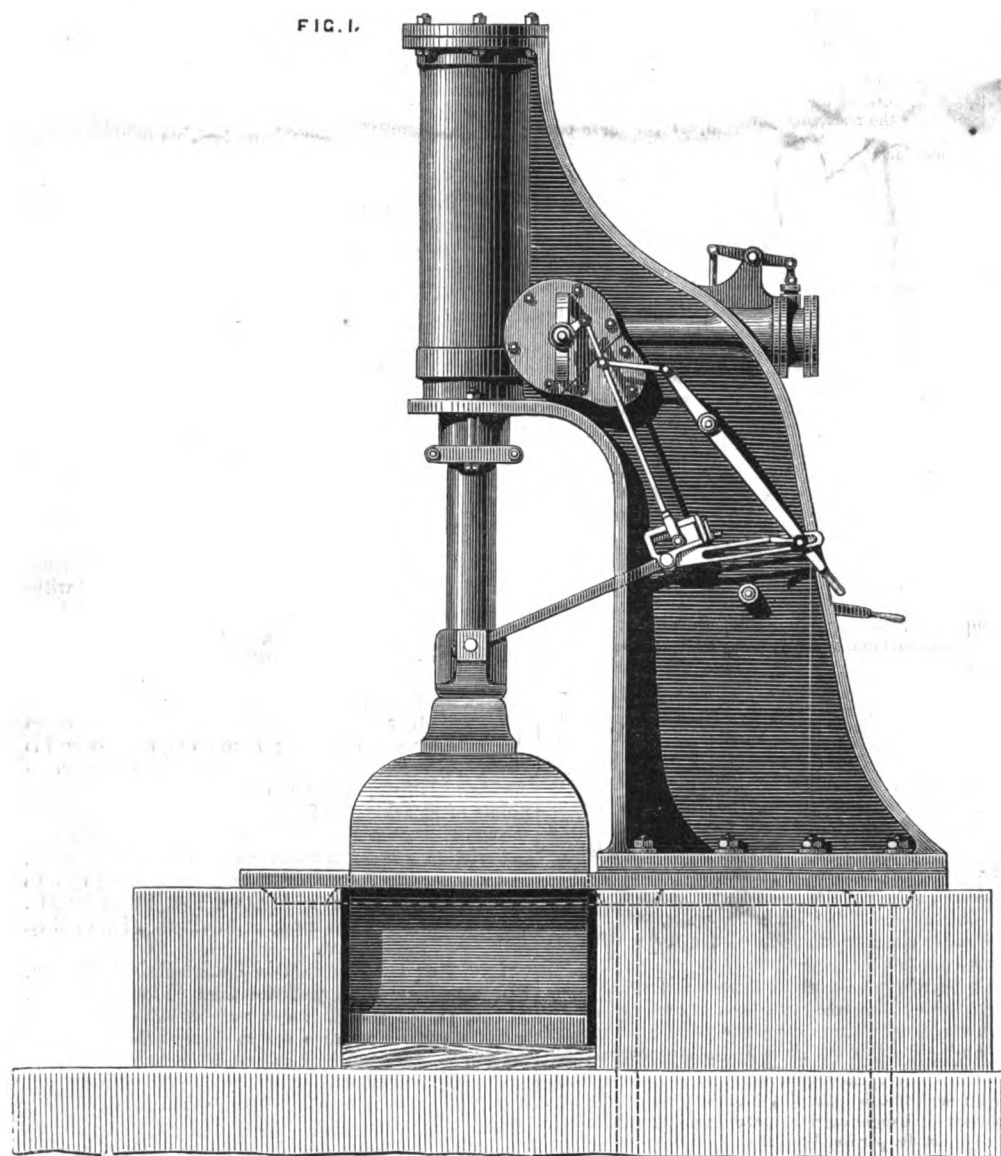
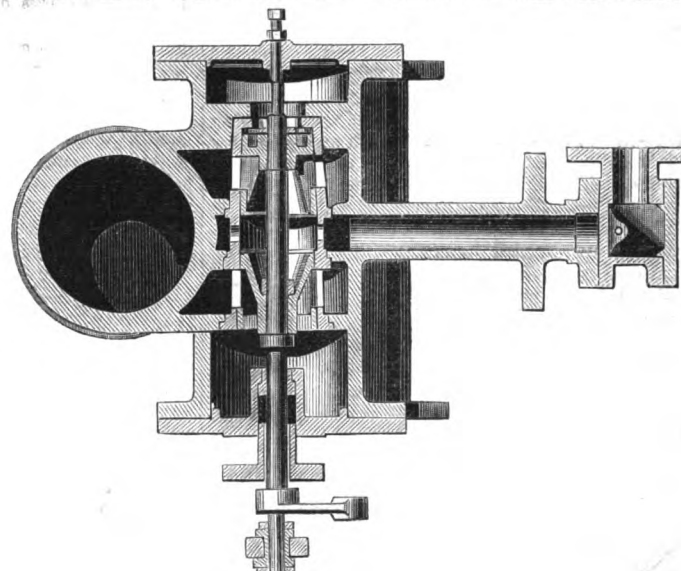
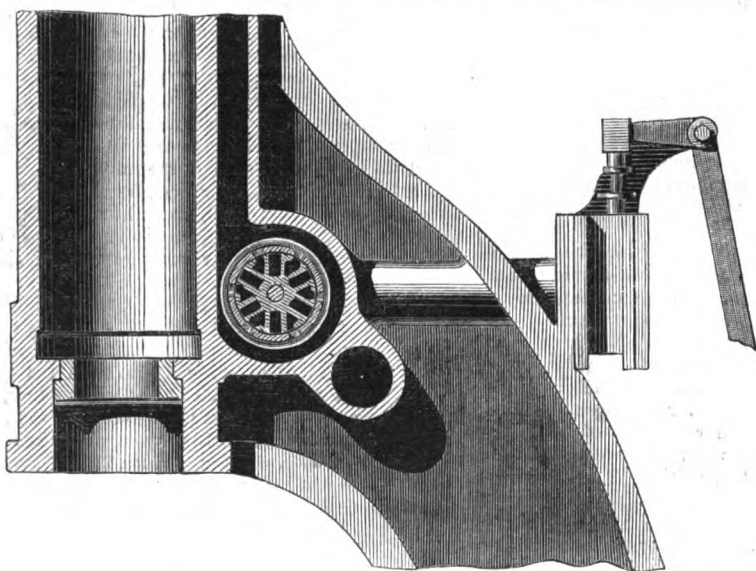
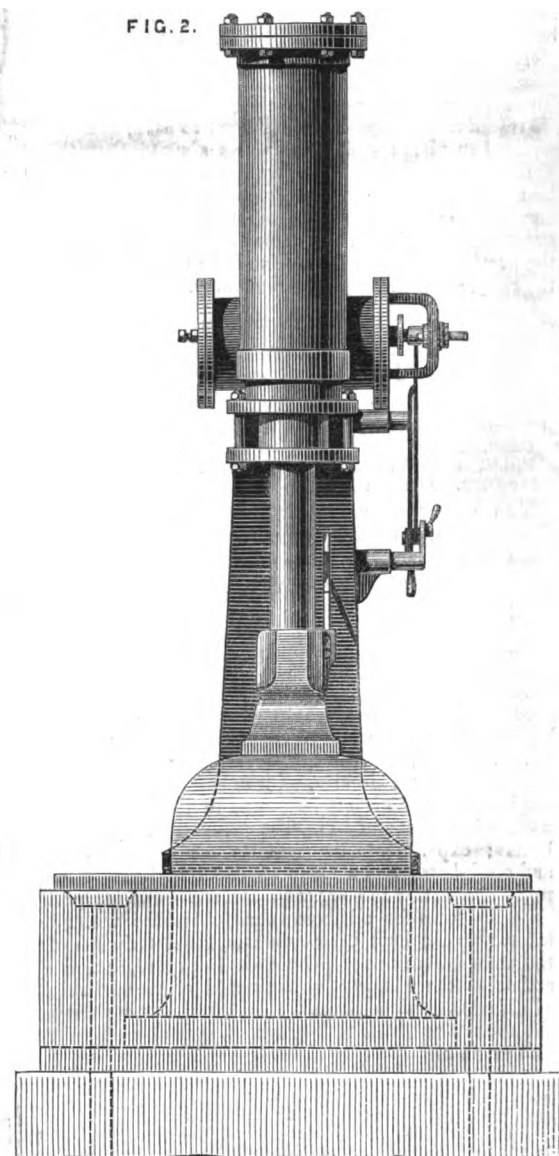


FIG. 2.



We give, above, engravings of an 8 cwt. double-acting steam-hammer, as constructed by Messrs. Tannett, Walker, and Co., of Leeds, the main feature in this hammer being its self-acting valve-gear, which, whilst capable of great accuracy of adjustment, is yet extremely simple. The general arrangement of this valve-gear will be seen from the side elevation of the hammer, whilst the construction of the valve, by which the distribution of the steam is effected, is shown by the enlarged sections.

Referring to these latter views, it will be seen that the steam from the boiler, after passing the gridiron-valve forming the regulator, is conducted through a passage cast in the hammer-framing into a chamber surrounding the central portion of the distributing-valve. This valve, which is of a conical form, works in a correspondingly formed face fitted into the hammer-framing. The valve face is perforated with three rings of openings, the central openings communicating with the steam-

chamber already mentioned, whilst those forming the other two rings lead to the top and bottom steam ports of the hammer-cylinder respectively. The valve itself is really formed in two portions, carried by a central spindle, which can be adjusted lengthways to take up any slackness caused by wear, these portions governing the admission of the steam to, and its release from, the top and bottom of the cylinder respectively.

The steam is admitted from the annular chamber, through the central openings in the valve face, into the space between the two portions of the valve, and according to the position of these latter it is admitted to the top or bottom of the cylinder. From the peculiar shape of the valve in cross section, either of the two portions is capable of uncovering six openings for the admission of steam into its respective port, or of forming six passages between that port and the exhaust. The exhaust-pipe, we should state, is in communication with the two chambers situ-

ated at the ends of the valve. In the enlarged sectional plan of the valve, the top port of the cylinder (that towards the bottom of the engraving) is shown in communication with the exhaust, and the bottom port with the steam-chamber. It will be readily seen by an inspection of the engravings how, by the vibrating motion given to the valve, this state of things will be reversed, the top port being placed in communication with the steam-chamber, and the bottom port with the exhaust; and it only remains to explain how this vibrating motion can be regulated in extent so as to govern not only the amount of opening of the valve, but also the point of the stroke at which that opening shall take place.

These adjustments are effected by two distinct arrangements, one of them regulating the extent of the arc of vibration of the valve, or what we may term the length of its stroke, and the other virtually lengthening or shortening the rod by which the

arm on the valve-spindle is connected to the actuating lever. It will be seen by the side elevation that the lever by which the valve is actuated vibrates upon a pin fixed to the hammer-frame, and that one end of it works through a pin carried by the hammer-head. The motion communicated to the lever as the hammer-head rises and falls is transmitted to the valve by a jointed rod, or rather pair of links of unequal length, forming a sort of toggle-joint. At the point where the links are coupled to each other, another link is connected to them, the other end of this link being attached to a lever, as shown in the elevation. By moving this lever—which is furnished with a slotted guide and fixing screw—the two links forming the toggle-joints can be drawn out of line with each other, and their effective length—regarding them as a connexion between the arm on the valve-spindle and the actuating lever—thus reduced. The effect of thus moving the links of the toggle-joint out of line is to turn the valve partially round in its seat, and virtually to reduce the lap of that portion governing the admission of steam to the top steam-port, the consequence being that, as the hammer-head rises, that port is uncovered for the admission of steam earlier than it otherwise would be. The bottom port is also put into earlier communication with the exhaust.

The stroke of the valve, and consequently the amount of opening given to the ports, is regulated by shifting the lower end of the lower link of the toggle-joint, in the slotted lever to which it is attached, a screw being provided, as shown in the engravings, to enable this to be done readily. The effect of thus shifting the end of the link is to lengthen or shorten the arm of the lever by which the motion is imparted to the valve.

From the entire absence of tappets, or their equivalents, in the valve motion we have described, it works very quietly, and is very unlikely to get out of order. It is also, as we have said, very simple and readily adjustable, and is, we believe, found to work very satisfactorily in practice. Our engravings of the hammer and valve-gear have been prepared from tracings for which we are indebted to Messrs. Tannett, Walker, and Co.

TRACTIVE RESISTANCES ON RAILWAYS.

(Continued from page 340.)

Resistance of Locomotives and Tenders to being put into Motion.

The following values of the resistances to starting were obtained by applying the power for putting the engines and tenders into motion as gently as possible:

	Coefficients of Resistance.	
	kilogrammes per tonne.	pounds per ton.
1st. Mixed engine	15.9	= 35.616
2nd. Goods engines with six coupled wheels	19.7	= 44.128

Generally in actual service the power required to put an engine and tender in motion is much greater than above given, as, in addition to the frictional resistances having to be overcome, a certain power is expended in accelerating the speed of the mass.

Resistance of Tenders alone.

Experiments were also made, by the aid of the dynamometer, upon tenders detached from the engines. The mean resistances were found to be as follows:

	Coefficients of Resistance.	
	kilogrammes per tonne.	pounds per ton.
In kilometres per hour.	In miles per hour.	
30	= 18.6	... 5.16 = 11.558
45	= 27.9	... 7 = 15.68

Resistance of Trains in general.

For measuring the resistance of trains recourse was had to the dynamometer, the experiments being only conducted according to the second method. There were obtained thus the tractive strains upon the drawbar of the tender.

The authors refer to their complete paper for an account of the details of the mode of experimenting, and also for the calculations. It may be stated, however, that the trips made by the trains were divided into equal sections of half a kilometre (about $\frac{1}{4}$ of a mile) each, and that the speed and amount of work done was calculated for each of these sections.

When the line travelled over had almost constant profile throughout its course, and there was but little variation in the speed at which the train was run, there could be calculated,

- 1st. The mean resistance of the train throughout its course;
- 2nd. The mean speed;
- 3rd. The mean tractive effort exercised by the draw-bar of the tender.

Knowing the gross weight of the train in tons, there could thus be deduced the resistance per ton of train.

In the case of the greater part of the trials the line was not exactly level. It was decidedly established, however, that the effect of rising gradients is to augment the resistance exactly 1 kilogramme per tonne for each millimetre of rise per metre, and thus the correction done to the action of gravity could be deducted in each case, leaving the coefficient due to the resistances on a level.

The total distances run with the experimental trains were as follows:

kilometres.	miles.
1360	= 843.2 with goods trains
461	= 279.02 " mixed "
1501	= 930.63 " passenger "

Total ... 3319 = 2053.44

The total number of trains was 139.

Experiments with Goods Trains.

The gross weight of the trains varied from 152 to 571 tonnes (149.2 to 560.8 tons English). The number of vehicles in each train varied from 12 to 56; and there were trains completely empty, others partially filled, and others completely loaded.

The proportion of platform wagons in the trains varied

from 0 to 97 per cent.; and the proportion of wagons having their axles lubricated with oil, from 2 to 100 per cent.

The inclination of the line varied from a downward inclination of 1 in 1000 to a rising gradient of 1 in 50. The radius of the sharpest curves was 400 metres (1312 ft.).

The temperature varied from -4° to $+26^{\circ}$ Centigrade (24.8° to 78.8° Fah.), and there were during the experiments calm weather, slight winds, high winds, dry weather, rain, hail, and snow.

The speed at which the trains were run varied from 10 to 39 kilometres (6.2 to 24.18 miles) per hour.

The experiments were thus carried on under circumstances widely varying.

Let us group together the trains which were experimented upon under favourable circumstances, and take the mean. Letting f denote the resistance per ton of train on a level, we have:

Speeds.	Coefficients of Resistance.	
In kilometres per hour.	In miles per hour.	kilogrammes per tonne. pounds per ton.
17 to 26	= 10.54 to 16.12	... $f=3.15$ = 7.06
26 " 32	= 16.12 " 19.84	... $f=3.95$ = 8.84

From this it is concluded that at their mean speed, during regular service, these trains have a mean resistance of 3.55 kilogrammes per tonne=7.95 lb. per ton English. The various influences which aggravate the resistances of goods trains have also been investigated separately; at present, however, it will merely be necessary to say concerning them, that these resistances are sometimes augmented to about 8.6 kilogrammes per tonne=19.264 lb. per ton English.

Experiments on Passenger Trains.

The gross weight of the trains experimented upon varied from 30 to 118 tonnes (29.46 to 113.8 tons English); and the number of vehicles per train, from 5 to 20.

The proportion of vehicles having their axles lubricated with oil varied from 7 per cent. to 100 per cent.

The inclination of the line varied from a downward incline of 1 in 1333, to a rising gradient of 1 in 100. The minimum radius of the curves was 700 metres (2296 ft.).

The speed varied from 24 to 77 kilometres (14.88 to 47.74 miles) per hour.

Grouping together the trains experimented upon under circumstances favourable for reducing the tractive resistances, and taking the mean, and distinguishing between short trains (consisting of from 8 to 10 carriages) and long trains (consisting of from 14 to 17 carriages), we find,

1st. Short trains:

Speeds.	Coefficients of Resistances.	
kilom. per hr.	miles per hr.	kilo. per tonne. pounds per ton.
V = 46	= 28.12	$f = 7.21$ = 16.15
V = 58	= 35.96	$f = 9.57$ = 21.44
V = 76	= 47.12	$f = 14.55$ = 32.57

2n. Long trains:

Speeds.	Coefficients of Resistance.	
kilom. per hr.	miles per hr.	kilo. per tonne. pounds per ton.
V = 45	= 27.9	$f = 5.98$ = 13.39
V = 52	= 32.64	$f = 6.53$ = 14.63
V = 60	= 37.2	$f = 8.05$ = 18.03

It will be seen from these tables that the resistances of passenger trains increase rapidly with the speed, and that they are also rapidly augmented as the trains are shortened.

In calm weather upon a line which is in good order, and in which the curves are at least 1000 metres (3280 ft.) radius, the coefficient of resistance on a level is, in the case of an express train with eight carriages, about 14.55 kilogrammes per tonne (=3.59 lb. per ton English).

Let us now pass on to the other questions of the programme.

"To determine separately the influence of each of the conditions of traction mentioned in the first question. To analyse the causes which in curves modify the resistances, conducting the examination by reasoning and by experiments."

Experiments were conducted to ascertain the resistances due to the various parts of engines.

Each engine was tried without its tender, in road-worthy condition; and was drawn behind the wagon fitted with the dynamometer.

On the first run, the engine was drawn with all its mechanism coupled up. On the second run, the connecting-rods were uncoupled.

On the third run the coupling-rods were disconnected.

On the fourth run both the connecting and coupling rods were uncoupled.

From these four trials it was possible to deduce:

1st. The resistance of the engine completely coupled, but without tender;

2nd. The frictional resistance due to the coupling;

3rd. The frictional resistance of the pistons, crosshead-guides, and connecting-rods (the frictional resistances obtained, however, being those due to the working of the mechanism when not exposed to the pressure of the steam);

4th. The resistance of the engine when running without its mechanism, that is to say, considered as a vehicle.

The results are as follows:

1st. At a speed of 28 kilometres (17.36 miles) per hour, the resistances of the engines were:

	Coefficients of Resistance.	
	kilogrammes per tonne.	pounds per ton.
Mixed engine	9.6	= 21.5
Goods engine with six-coupled wheels	12.3	= 27.33

2nd. The resistance due to the coupling of the wheels was not determined with sufficient accuracy to enable any conclusions to be arrived at. It may be observed, however, that when running on a straight line the resistance due to this cause was very slight.

3rd. For the mixed and goods engines the resistances due

to the friction of the pistons, connecting-rods, and crosshead-guides amounted to 48 per cent. of the total resistances of the engines when completely coupled up. The pistons were of the type known as the Swedish.

4th. The resistances of the engines, when reduced to the condition of vehicles, were:

	Coefficients of Resistance.	
	kilogrammes per tonne.	pounds per ton.
Mixed engine	5.23	= 11.69
Goods engines with six-coupled wheel	6.15	= 13.77

These coefficients were obtained at speeds varying from 25 to 30 kilometres (15.5 to 18.6 miles) per hour.

Causes which produce Variations in the Coefficients of Resistance of Wagons.

On a straight and level line the normal resistance of wagons is composed of two elements:

- 1st. The friction of the wheels;
- 2nd. The resistance of the air.

When working at low speed the second element may be neglected, and the resistance considered as due only to the frictional resistances which are expressed by the following known formula:

$$(3) R = (p + p')f' + f'' \times \frac{d}{D}$$

in which

- p = weight of the wagon without the wheels;
- p' = weight of the wheels;
- d = diameter of the axle-journals;
- D = diameter of the wheels;
- f' = coefficient of the rolling friction of the wheels;
- f'' = coefficient of the friction of the axle-journals in their bearings.

Friction of Axle-boxes Lubricated with Oil.

It has been found by the method of laying down the curves of acceleration, that the resistance of a wagon moving at a speed of from 1 to 5 kilometres (0.62 to 3.1 miles) per hour is 11 kilogrammes per tonne=24.64 lb. per ton English. In applying the equation (3) we may suppose, according to Wood, that $f''=0.001$, and we find

$$f''=0.018,$$

which is the coefficient of friction in an axle-box lubricated with oil, and at a temperature of 20° Centigrade (68° Fah.).

Friction of Axle-boxes Lubricated with Grease.

The application of the same method gives for the friction of an axle-box lubricated with grease, and at a mean temperature,

$$f''=0.032.$$

This coefficient is almost double the preceding one.

Influence of the Load upon the Friction of the Axles.

The weights of the wagons varied considerably during the experiments on goods trains; but it was found that the coefficients, f'' , were but slightly different under the different loads. It is concluded, therefore, that the friction of the axles is unaffected by the load upon them so long as this load is not so great as to cause seizing.

Friction of the Axle-boxes of an Engine.

For an engine weighing 30 tonnes (29.46 tons English) it was found that at speeds of from 25 to 30 kilometres (15.5 to 18.6 miles) per hour, the value of f'' was

$$f''=0.052.$$

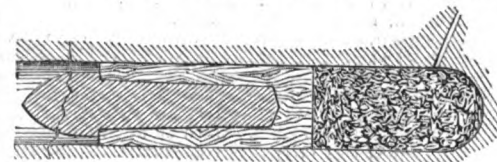
The axle-boxes were lubricated with oil.

(To be continued.)

LARGE-BORE GUNS.

TO THE EDITOR OF ENGINEERING.

SIR,—Why not use, in the 15 in. or any other smooth-bore cannon, an elongated shot, heavy at the front and encased in a wood sabot, the same as the projectiles used in the famous needle-gun, and encased in a paper sabot? If it is possible to make the shot so heavy at the front and so long that it will keep end on, and reduce the diameter so as to keep the weight the same; that is, to use only a 10 in. or a 9 in. shot in the 15 in. gun, and a pointed chilled shot at that, then a 750 lb. or 500 lb. shot, propelled by 100 lb. of powder, ought to do more execution than a much lighter shot thrown with but 30 lb. or 40 lb. of powder. The enclosed sketch will convey the idea.



The sabot to leave the shot, or, more properly, the shot to leave the sabot when both are well out of the gun; to insure such a result, it might be best to make the latter in two or three pieces. The danger to be apprehended is that the wood might wedge in between the shot and gun, and burst it; but that would be governed by the angle of the butt and shoulder on the shot, and the kind of wood or other material used for the sabot. The force of the powder would expand the sabot so as to prevent windage and carry the shot not only free from the sides of the gun, but perfectly central and true with it. A sheet of tin the size of the bore, placed on the butt of the sabot would prevent the escape of gas through the joints or pores in the wood. I send you this, supposing it to be new, though shall not be greatly surprised to hear that it is an old and exploded idea. If it is new, you may find room for it in your paper, and through that it may find its way to some one who can afford to try the experiment; if it is old, find room for it in your waste-paper basket.

I am, &c.,
J. E. S.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig Iron Market.—Since my last communication the pig iron market has undergone a very decided change—one that seems to have a ray of hope about it amidst the general stagnation which prevails here and in other important manufacturing towns in Scotland. This day week the prices varied from 54s. 4d. to 54s. 7d. cash, and from 54s. 6d. to 54s. 9d., payable in a month. On the following day the market was very firm, and the prices advanced to 54s. 9d., and even to 55s. 14d. cash, and to as high as 55s. 4d. at a month; and since then there has been no material variation in prices. Ardrossan shipments for the week ending 10th October were 3114 tons, including foreign shipments to the extent of 971 tons; from Glasgow, for the week ending the 12th October, there were 1831 tons shipped, including 806 tons for foreign orders. From the whole of the Scotch ports, for the week ending 15th October, there were shipped 11,181 tons as against 12,875 tons for the corresponding week last year; and the total since 25th December, 1866, was 504,919 tons, while the corresponding period in 1865-6 was 465,142 tons. There were no shipments of pig iron last week at Greenock; but the shipments of coal were considerable; and from the same port, or rather from the Tail of the Bank, for the month of September, the shipments of gunpowder amounted to 213,200 lb.

Leith Dock and Shipping Affairs.—At the last monthly meeting of the Leith Harbour and Dock Commissioners, and at an adjourned meeting of the same body, held yesterday, a very strange proposal from the Caledonian Railway Company was considered, and received the *quiescent*, as it deserved. It was a proposal to throw a railway bridge across an important part of the harbour, below the entrance to the Old Dock. At the adjourned meeting Ex-Provost Lindsay said that, on the site of the proposed bridge being fixed by the Dock Commission, he had lodged the following reasons of dissent, which I annex, as they show with great fairness what was really intended by the proposed bridge:

"1. Because I believe it is an excess of power on the part of the Commissioners for the Harbour and Docks to make a railway bridge across the highway or fairway of the port of Leith. Parliament only can sanction such an interference with the public rights. No intimation has been made to the public of the proposed bridge.

"2. Because the erection of the bridge across the fairway of the port on the proposed site will sacrifice to a great extent not only the general trading interests of the older parts of the port, particularly the Old Dock, but the existing valuable properties situated thereon, all for the benefit, unintentionally no doubt, of a railway interest and the larger class of vessels going to the New Docks.

"3. Because it is inequitable and unjust to expend the shipping dues for the proposed railway bridge, the cost of which, with the relative works, will not be less than 20,000*l*.

"4. Because, in any view, there is already railway communication betwixt the east and west sides of the harbour (made at the expense of the railway interest), and the site thereof, with a slight deviation, as shown in the plan prepared by the harbour engineers, is a right and proper site for any improved railway communication which may in course of time be required."

Mr. Lindsay maintained that the charters of the commission did not give them any right to a public river. The Upper and Lower Drawbridge, the Stone Bridge, the Victoria Dock, and the extension of the piers were all executed with the sanction of Parliament.

The shipping of the port of Leith has of late been increasing scarcely any. The arrivals and sailings during August, of which the returns are just published, vary very little from those of August, 1866, so far as the tonnage is concerned, although there is a small increase on the port duties for the month.

People in Leith and Edinburgh are not much accustomed to see the big steam vessels which we build on the Clyde, and they have consequently got a little excited regarding the *Cimbria*, the last addition to the magnificent fleet owned by the Hamburg-American Company. The *Cimbria* has just been overhauled in the Prince of Wales Graving Dock, Leith, where she was inspected by a large number of people. She is commanded by Captain N. Trautmann, and has 180 for a crew. The *Cimbria* left Hamburg on Sunday week, about mid-day, and although encountering strong head winds during the greater part of the voyage, accomplished the passage—a distance of nearly 420 nautical miles—in thirty hours. The vessel was built by Messrs. Caird and Co., of Greenock, which eminent firm have supplied the Hamburg-American Company with steamers during the past thirteen years. Her length is 330 ft., breadth of beam 40 ft., and depth of hold 34 ft. The engines are of 500 horse power, but during her trips from port to port have indicated as high as 2200. She has four decks, and has accommodation for 60 first-class, 120 second-class, and 550 steerage passengers. Besides her full complement of passengers, the *Cimbria* carries 1100 tons of coal in her bunkers, and has storage for 1000 tons of goods. When at sea, she consumes sixty-five tons of coal every twenty-four hours. The vessel is equally heated by means of steam pipes, and the ventilation in every part is perfect. The saloon, which is gorgeously fitted up, is 90 ft. in length. The sides are decorated with beautifully executed landscapes in oil, elegant bronze statues, and rich gilt mouldings. At the further end of the saloon is placed a handsome pianoforte for the use of the first-class passengers. Each state-room is furnished with two patent-spring beds. Her apparatus for distilling salt-water is capable of producing 1000 gallons a day. Since April last, the *Cimbria* has made four trips between Hamburg and New York. Her rate of speed has been on an average 14 knots an hour; and she is said to have made the quickest passage between New York and Southampton of any steamer on record, having accomplished the distance from port to port in nine days and four hours. She cost 90,000*l*. The same firm, which has so long and so deservedly secured the patronage of the Hamburg-American Company, has at present on the stocks another vessel, to be named the *Albatros*, of the same type with the *Cimbria*, but 10 ft. longer, and having 100 additional horse power. I mention these details regarding the *Cimbria*, because she is one of the

noblest specimens of naval architecture that the Clyde has ever furnished.

From Friday to Monday evening last upwards of sixty ships arrived in the port of Leith, and of these twenty-one were laden with timber. For some time before the day first mentioned, westerly breezes had continued to prevail. Should eastern winds continue for the next fortnight, many arrivals may be looked for, as a large fleet of sailing ships are on the way.

Scientific Education.—The director of the Edinburgh Museum of Science and Art has begun to follow in the footsteps of his eminent predecessor, the late Professor George Wilson, by showing a wish to turn that portion of the museum to advantage which was formerly called the Industrial Museum, in connexion with which Dr. Wilson had the Professorship of Technology. Unfortunately, that amiable and able man of science died too early for the subject and office which he loved so well. He intended, as I know from intercourse with him, to turn the almost invaluable collections of industrial products under his care to the very best advantage, by means of systematic lectures and demonstrations upon them, both to his college students and to the artisans of Edinburgh and those who might occasionally visit the city. I am glad to be able to announce that Mr. Archer, the present director of the museum, has succeeded in making arrangements to have short courses of lectures on special departments of science delivered during the ensuing winter in connexion with the museum, to working men, somewhat on the plan of the working men's lectures in the Royal School of Mines, Jermyn-street, London. The first course of six lectures will be on chemistry, the lecturer being Dr. Lyon Playfair, the Professor of Chemistry in the University of Edinburgh. From Dr. Playfair's life-long devotion to the technical applications of the principles of his favourite science, his lectures should prove a great treat. They are to be followed by a short course on physics, I think, and others will follow them.

State of Trade at Greenock.—Trade is at present remarkably dull, and a large number of workmen are out of employment. In the ship-carpenter business, out of above 700 workmen, only about 150 are employed. In the shipbuilding trade a large number of men have been paid off lately from the yards of Messrs. Steele and Co., Caird and Co., &c. The former firm, however, during last month received contracts for four large iron ships. The keel of one of these has been laid, and the others will follow; so that in the course of a month or so the firm will be as busy as ever. Messrs. Scott and Co. have nothing on hand; Messrs. Robertson and Co. and McNab and Co. have each two vessels finishing. The engineering trade is also very dull. The sugar-refining trade is scarcely so busy as in previous months, and two of the sugar houses are expected to be closed for a month or two, during which time they will undergo improvements and additions. The shipping trade is as dull as the others, and at present only four sugar-laden ships are discharging, while three weeks ago one ship-owner alone had ten vessels of 7000 tons in his fleet, all in port with sugar. The harbours are now very slack, and a great many of the labourers are out of employment. The timber ships, however, are expected in the course of next month, so that, although so many men are idle at present, it is expected that in a month or two, at least, two-thirds of those unemployed will resume work.

State of Trade in Coatbridge.—Trade throughout the Coatbridge district is little changed of late. The prospects which were formed of the winter trade have not been realised to any extent, and firms which are fully employed, as a rule, at this season, have few orders of any importance on hand, while some are adding to their stock rather than part with their best workmen. Even the most extensive houses in the forge, tube, shovel, and file branches, suffer from the depression. As far as the iron trade is concerned, the present season is generally admitted to be one of the worst of the last half century. The malleable iron trade has somewhat revived during the last week or two, and there is now a fair demand for iron and rails for export, but very few orders are arriving from the Clyde shipbuilding yards. The stocks of pig iron at Gartsherrie, Langloan, Summerlee, Calder, Dundyvan, and Carnbroe, are said to be gradually diminishing, owing to the late increase in price, and greater demand. The boiler yards are almost at a standstill. In the tin-plate works, however, the orders are still tolerably good, and, as a rule, all hands are fully employed day and night. In the coal trade of Coatbridge and the Wishaw districts, dullness is the order of the day, and even with the near approach of winter some of the pits are being closed up, and large numbers of colliers thrown idle.

State of Trade in Kirkcaldy and County of Fife.—Trade in Fife is becoming much depressed in its different departments. At the present time, the stagnation that prevails is quite alarming in regard to both the mill-spinning and manufacturing interests. Those engaged in the former are now in many cases inclined not only to stop portions of their machinery, but to put the balance on short time, in the expectation that this great reduction in the consumption would have the effect of bringing down the price of the raw material—a result that cannot certainly be looked for if the present rate of consumption is continued. In the district of Kirkcaldy, which is suffering more perhaps than any other part of the county from the depressed state of trade, business has become quite paralysed. Not only are the leading mill-spinners and manufacturers talking of stopping altogether about the half, or putting on short time the whole, of their machinery, but in the other branches of trade a standstill would appear inevitable at no very distant day. The engineers, who have of late been gradually paying off their hands, have now completed nearly the whole of the orders they had booked, and that without the slightest appearance of any fresh ones coming in. In the different towns and villages throughout the county large numbers of the "black" class of tradesmen parade the streets in absolute idleness, while too many more from other parts of the country may be met with in quest of what they have not the slightest chance of obtaining—employment. With regard to shipbuilding, prospects are no brighter. The coal trade of the county, in which several thousands of the population are engaged, and on which many thousands more depend, has of late become worse in consequence of the public works going on short time. A good demand for foreign ports exist; but from

the scarcity of vessels, owing to the few home freights, there is no possibility of its being properly met. On the Tay, as well as on the Firth of Forth, this great scarcity of vessels to supply the Continental demand is felt. Taking the whole of these circumstances into account, it may be said with safety that trade has not been so backward in this quarter for at least the last eight years, and, with a scarcity of work and high provisions, it is to be feared that a hard winter is in store for those of the working population of our towns and villages who have not made the necessary provision for the apparently impending crisis.

The New Waterworks at Fort Glasgow.—These works, which were opened yesterday (Tuesday) with some ceremony by the authorities, were commenced eighteen months ago, Mr. James M. Gale, engineer to the Glasgow Water Commissioners, directing the engineering details. Under the agreement the works were to be completed at the end of September of the present year, but the operations were carried on to such advantage that Mr. Murray, the contractor, secured for himself a premium by fulfilling his engagement several weeks within the stipulated period. The waterworks consist of a large reservoir, near the farm-stead of Leperstone, at the top of the main valley of the Finlaystone Burn, and a large filter and tank at the farm of Parkhill. The works are capable of supplying 12,000 people with 30 gallons of water a head per day, or 360,000 gallons a day. The reservoir, which is 33 ft. above the mean level of the sea, covers an area of 26 acres, and is bounded by two embankments (one at the north and the other at the south end), the largest one, that at the south end, being 250 yards long and 204 ft. deep. The reservoir will contain 8,800,000 cubic feet of water, a quantity which will yield a supply to a population of 12,000 for a period of more than one hundred days without rain. The drainage area, which includes a diversion of the Finlaystone Burn, is about 300 acres, and, should the works come to be extended, the drainage area can be increased to about 450 acres. The waste weir is situated at the end of the south embankment, and the surplus water flows back into the streams that lead to the Gryfe. A large stand-pipe, 3 ft. 6 in. in diameter, is situated at the other embankment, and by means of this pipe the water in the reservoir can be drawn off at three different levels. Upon the outside of the north embankment there is a gauge well, which has been constructed for ascertaining the exact quantity of water that leaves the reservoir. From this well the water is conducted in earthenware pipes (15 in. in diameter) for the distance of one mile five furlongs to the filter and service tank at Parkhill. The works here consist of a filter and tank; but before the water falls into the filter it passes through another gauge well, so that any leakage which may take place between the reservoir and the well can be at once discovered, and the quantity of water gauged that passes through to the town. The filtering materials are composed of whinstone, metal, gravel, fire-clay tiles, and Brodick sand. The tank is a circular one, built of 18 in. ashlar walls. The water in the tank is 256 ft. above the sea, and with this pressure the highest houses in the burgh can be supplied with water. From the tank the water is led through a 9 in. iron pipe for two miles and one furlong, and distributed through the different streets of the town.

Glasgow Gas.—The Town Council having recently resolved that the Inspector of Gas Meters should periodically exhibit information as to the quality, illuminating power, &c., of the gas supplied by the gas companies, Mr. Campbell, the inspector, will now furnish to the newspapers weekly a statement of the illuminating power of the gas of each of the companies, and the price charged per 1000 cubic feet. Mr. Campbell has also been directed by the Town Council to procure from the large towns information as to the illuminating power of the gas supplied, and the price charged per 1000 cubic feet, and to tabulate the information monthly, and supply the tables to the newspapers. The following is the report by the inspector for five weeks:

Illuminating Power of the Gas supplied in Glasgow, from the 5th to the 13th September.

	Strd. Candles.
Glasgow Gas Light Company, average	27.9
The minimum being 25.7, and maximum	29.1
City and Suburban Gas Light Co., average	26.7
The minimum being 25.4, and maximum	27.9
From the 14th to the 20th September.	
Glasgow Gas Light Company, average	30.8
The minimum being 26.8, and maximum	34.9
City and Suburban Gas Light Co., average	29.6
The minimum being 26.6, and maximum	33.5
From the 21st to the 27th September.	
Glasgow Gas Light Company, average	31.8
The minimum being 28 and maximum	35.7
City and Suburban Gas Light Co., average	29.9
The minimum being 27 and maximum	33.3
From the 28th Sept. to the 4th Oct.	
Glasgow Gas Light Company, average	30.9
The minimum being 28.6, and maximum	33.4
City and Suburban Gas Light Co., average	28.4
The minimum being 27 and maximum	29.9
From the 5th to the 11th Oct.	
Glasgow Gas Light Company, average	29.0
The minimum being 26.9, and maximum	30.2
City and Suburban Gas Light Co., average	26.7
The minimum being 26.1, and maximum	27.2

I give this table as an example to other towns, and at present to show what kind of gas we get in this city. Any other town may do the same under Lord Kamesdale's Act.

NEW ENGINES FOR THE NORTH LONDON RAILWAY.—We understand that Mr. William Adams is now designing some locomotives of a new pattern for the North London line. They are to be outside cylinder engines with four coupled wheels and a four-wheeled bogie in front, and they will in their general arrangement much resemble American engines, except that they will have plate-frames instead of the bar-frames almost universally used in the States. There are at present but few outside cylinder engines on the North London Railway, and all the fine tank engines built by Mr. Adams during the last few years have inside cylinders.

INDIAN RAILWAY STATISTICS.

THE following particulars relative to the working of the guaranteed Indian railways will, no doubt, be read with interest. The first statement shows the mileage results for the year ending the 30th of June, 1866, and the second statement gives particulars regarding the traffic on the several railways during the first quarter of the present year, as compared with the similar portion of 1866.

Statement showing the Train-Mileage Results on all the open Railways in India for the year ending June 30, 1866.

	East Indian.	Eastern Bengal.	Calcutta and South-Eastern.	Punjab.	Great Indian Peninsula.	Sindh.	Bombay, Baroda, and Central India.	Madras.	Great Southern of India.
Miles open ...	11294	110	28	253	701	109	306	611	79
Train mileage ...	4,625,705	325,493	60,166	354,239	2,259,881	283,062	745,961	1,306,998	149,452
Gross earnings per train mile ...	8 8	7 7.85	8 8.935	5 0.72	10 9.625	6 8.21	11 4.695	6 8.575	5 0.5
Expenses ...	3 7.875	4 1.46	4 1.05	8 0.73	6 4.6	5 8.57	6 8.27	2 10.7	2 5.05
Profits ...	4 7.125	3 6.39	...	1 9.99	4 5.025	0 11.64	4 8.425	3 9.875	2 7.45
Loss ...	...	...	0 4.115	...	...	...	...	...	...
Percentage of expenses on earnings ...	44.32	53.95	109.13	60.49	59.09	85.48	64.87	43.06	48.01

From this statement it will be seen that the expenses per train mile, even on lines that are making nearly equal earnings per train mile, are by no means in proportion to their earnings. It may, however, probably arise partly from difference in the superiority of construction in the first instance, partly from better and more economical management, but in a great measure

it will be due to the relative cost of fuel on the respective lines. Thus, with the exception of the Madras Railway, the East Indian Railway, some of whose branches actually tap a portion of the most plentiful coal-bearing districts of India, will be found to work at a less rate of percentage on earnings than any of the other lines. One line only, the Calcutta and South-Eastern, does not pay its working expenses; and the Great Indian Peninsula line, which for percentage of profits on total capital stands second only

larity of rates of working expenses should cease, or at any rate become very considerably lessened.

The following statement will show the estimated average cost, over each of the undermentioned lines, of coal exported from England, and will serve to explain how a difference in the rate of working expenses on those lines may be, to a certain extent, accounted for.

Railway.	Average cost per ton on arrival in India.	Estimated average cost over the line.
Great Indian Peninsula	Coal 2 2 4 Coke 2 11 3 Patent fuel 2 7 1	£ s. d. 3 0 0 3 12 0 3 8 0
Madras	Coal 2 9 9½	3 0 0
Bombay and Baroda	" 2 8 0	2 18 0
Sindh	" 2 12 8	3 0 0
Great Southern of India	" 2 12 0½	2 18 0

The following statement shows that on four out of the nine lines of railway there was a falling off in the total earnings during the first quarter of 1867, as compared with the similar period of 1866, notwithstanding that in one case—that of the Eastern Bengal line—the mean mileage open was greater in the former than in the latter period. All the other lines show an increased average receipt per week per mile open, with the exception of the Great Indian Peninsula, which shows a falling off of £8.2, owing, no doubt, principally to a falling off in the cotton traffic.

The following is a comparative Abstract of Traffic on the Guaranteed Railways throughout India for the First Quarter of 1867 and 1866.

	East Indian.		Eastern Bengal.		Calcutta and South-Eastern.		Punjab.		Madras.		Great Southern of India.		Great Indian Peninsula.		Bombay, Baroda, and Central India.		Sindh.	
First Quarter.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.	1867.	1866.
Total earnings ...	£ 645,730	£ 570,408	£ 34,894	£ 35,412	£ 2,538	£ 3,371	£ 23,430	£ 27,849	£ 111,085	£ 107,873	£ 14,410	£ 8,585	£ 521,822	£ 512,656	£ 114,966	£ 117,719	£ 34,190	£ 28,030
Mean mileage open ...	1,131	1,129½	113½	110	28	28	246	253	645	611	127	79	831½	699	306	306	109	108
Average receipt per week ...	49,671	48,877	2,684	2,724	195	252	1,802	2,142	8,545	8,298	1,108	660	40,140	39,435	8,848	9,055	2,630	2,156
Average receipt per week per mile open ...	43.0	38.8	23.7	24.7	7.0	9.2	7.3	8.4	13.2	13.6	8.7	8.3	48.2	56.4	29.0	29.5	24.1	20.0

THE SOCIETY OF ENGINEERS.

W. H. LE FAUVER, Esq., President, in the Chair.

October 7, 1867.

The Quality of Iron as now Used. By EWING MATHESON.

(Continued from page 358.)

AND now comes the second proposition mentioned. The standards of excellence are too low. It is hardly worthy the reputation and genius of engineers that they should, knowing—as they doubtless must do—the different materials with which they might deal, mark a certain standard of excellence to conform with the mediocrity that generally does exist, instead of aiming at what may be, if they choose, and thus to lead the manufacturers of the country up to conform to their higher notions of what is good and best, for surely it is the province of professional engineers to take any good lead of this kind, and this because there is a quality of cast iron to be obtained in England which is now practically ignored. It has been seen that the quality of iron supplied generally ranges from 350 to 490 of the scale, and all this time iron can be had for the asking of 500, 550, and 600 strain. These even are not the highest figures to be obtained, as will presently be seen, but they are those which, leaving a margin of higher excellence, may be relied on as certain by an engineer who determines to have them. The difference between 600 and 490 is great enough, but when it is shown that a large quantity of iron manufactured is much below this, then, indeed, is there evidently a waste of time, labour, and space incurred by any one who is content with so little, and who is often completely in the dark as to the quality altogether. The writer has with him here a printed table, which is an extract from a report printed by order of the House of Commons in 1858, of the results of experiments made at Woolwich to obtain information useful in the manufacture of cast-iron ordnance. Fifty-one different specimens were carefully examined. They were taken from ironmakers in different parts of England and Wales, and tested for their transverse strength, for torsion, tension, and compression, and were in proportion as follows: The transverse strength varied gradually from a figure 9619 to 3075, or more than 2 to 1. The crushing strain varied from 130 to 50, the torsion 81 to 37, and the specific gravity differed as 7.2 to 6.8. The writer has not been able to ascertain the actual dimensions of bars and the weights in pounds, but quotes the figures to show the comparative value in the different kinds.

With these enormous differences existing, is it not monstrous that the competition in iron should be almost entirely uncontrolled, as it practically is? The extremes of high and low just quoted are not accidentally high and low ones, but the numbers range gradually and equably from top to bottom. It has been just stated that superior iron exists, but it is only after careful and oft repeated experiments that the assertion is ventured on. For convenience, the tests were carried out with Fairbairn's size of bar, and these bars were made as accurately as possible 1 in. square, and were placed on bearings, and loaded as in the diagram. No irons of an inferior kind were used, but ordinary good irons of reputed quality. The lowest result, therefore, was not very low, and the whole were as follows:

No.	One iron	lb.	in.	deflection
1.	Do.	425	1½	"
2.	Do.	512	1½	"
3.	Three irons mixed	570	1½	"
4.	One iron	605	1½	"
5.	Do.	613	1½	"

Some of these irons were good, and had been supposed to be good, but they are not the only ones to be given. The above tests were made more than a year ago, and, although conducted with care, were necessarily of somewhat a rude character. It was, therefore, determined to take advantage of some tests that were to be made at Mr. Kirkaldy's establishment to confirm or correct the conclusions already arrived at. It is not necessary here to describe the machinery in that place, it is now, doubtless, known to all London engineers, who need only to see to appreciate the cleverly contrived apparatus that with exquisite nicety tries every kind of mechanical strain up to hundreds of tons, and which at the same time records every change effected by increasing weight, and the final result that is obtained. The bars sent to Mr. Kirkaldy were not of the size used by Fairbairn, but of the more approved form previously alluded to 1 in. broad and 2 in. deep, while the length between bearings was only 3 ft., thus giving a very much stronger girder. It was resolved to test two qualities of iron—the first, an unmixed iron made from an unmixed ore of the best quality known to the writer, and the second, an inferior iron also from one single ore, but mixed with a portion of the superior metal first tested alone. Twelve bars were tested of each sort, and the results are given with all confidence as indisputable. It may be just mentioned that Mr. Kirkaldy measures the exact width and depth of each bar, so as to arrive at the exact value of the test, as it is impossible to cast the bars with mathematical similarity. By this measurement is obtained the figure of bd^2 , and this, for the purpose of argument here, is easily reduced to the standard of Fairbairn's formula. The bars of unmixed good iron stood as follows, they are now placed in their order of quality:

No.	bd^2	Breaking Weight.	Value of Mr. Fairbairn's S.	Ultimate Deflection.
1	4.202	4668	741	.374
2	3.998	4214	702	.353
3	3.960	4159	700	.411
4	4.039	4233	698	.375
5	4.120	4315	697	.386
6	4.413	4469	673	.352
7	3.959	3971	668	.394
8	4.000	3955	659	.318
9	3.998	3886	648	.373
10	3.920	3709	630	.316
11	4.120	3896	630	.341
12	3.998	3114	519	.264

The average of S here is 663; and if it had not been for the one exceptionally low bar, the average would have been 676, a remarkably high figure compared to the 500 which may be said to be the limit hitherto taken as practicable.

It is right here to mention that the writer has not himself verified that part of Fairbairn's formula which calculates by the

length in feet, and cannot therefore absolutely state that a 4 ft. 6 in. bar, 1 in. square, of the same iron would endure what is here given as S; but comparing the results now obtained with others made on bars of similar size, a very high quality is apparent.

The inferior iron, improved by its mixture with a portion of good, gave the following results.

No.	bd^2	Breaking Weight.	S.	Ultimate Deflection.
1	4.284	3718	578	.268
2	3.456	2863	552	.304
3	4.245	3844	525	.234
4	3.838	2908	505	.282
5	3.385	2489	490	.307
6	4.203	3070	487	.238
7	3.422	2431	476	.207
8	3.565	2491	471	.219
9	4.201	2932	470	.252
10	4.160	2891	475	.214
11	4.322	2902	449	.280
12	4.327	2688	412	.227

the average in this case being 490, a very respectable figure compared to what the weaker iron would have been without the mixture. Probably, by itself it would not have exceeded 390 or 400.

Having seen what superior iron exists, and its quality compared to that asked for by engineers, the third proposition is reached—

That where tests are given, they are often not duly exacted. And it may be at once stated boldly, that in some cases there is not even a pretence of carrying them into practice. The engineer has specified them so as to have a power to reject what is notoriously worthless; but if the work goes on pleasantly, and the castings are smooth and clean, with no apparent flaws, no actual test is made at all. Some are not as lenient as this; but, while letting stanchions and columns pass, rigidly test all girders and castings that take a transverse strain. In subjecting these to an actual dead weight, of course certain positive information is gained, but to a very limited extent; for if the castings are strained only to something beyond their mere working load, only flaws and manifest deficiencies are discovered, and the ultimate value is as far as ever from being known; for the only real way of testing irons is to break them, and it would be rather an expensive process—to say nothing of difficulty—to break heavy columns and girders. But where actual breaking loads are applied by hydraulic pressure, there is generally the greatest difficulty in correctly recording the results. The apparatus used is probably only reluctantly made at all by the manufacturer, and is often of a very rude kind, the load being calculated by the small round safety-valve of the pump, where the most exquisite nicety of dimension is needed, and where the greatest facilities exist for "cooking" the account of load. Of course, theoretically, nothing is more easy than to demonstrate by the length of lever, &c., what is the total pressure given; but those who know the working of these presses are aware of the difficulties that prevail. For instance, the diameter of the valve, on which all the calculations are based, is perhaps only in., and its area may alter directly it, by any slight jerk, is

raised at all. The knife-edge steelyard, as sometimes but rarely used, is also often deficient, and gives misleading results. The admirable machinery that has been contrived and set to work by Mr. Kirkaldy, at his proving works, in Southwark, not only succeeds in itself, but shows, beyond question, how totally wrong must have been many of the data hitherto taken for granted, but which, through deficient apparatus, have been erroneously obtained.

(To be continued.)

MACHINERY IN THE FRENCH EXHIBITION.

TO THE EDITOR OF ENGINEERING.

SIR,—The mechanical productions of French and Continental engineering firms, as exhibited this year in the Champ de Mars, have from the earliest days of the Exhibition given rise to much comment both in public prints and in private conversation, owing to the opinion entertained by many that the Continentals had entirely overtaken us, and that this particular branch of industry, which had hitherto been considered to belong almost exclusively and as it were by right to the English nation, was either gradually leaving us, or would soon leave us, and be appropriated by the Continent.

It certainly cannot be said that ingenuity in the combination of mechanical movements has been wanting on the Continent—the fruits of the inventive genius of our neighbours are too numerous to admit of any question on that point; but this kind of ingenuity only constitutes one portion of mechanical genius, the other elements of it being the proper appreciation of the proportion of parts, and the knowledge of executing the work with accuracy and care in such manner that the machine shall form a harmonious whole, able to perform the greatest possible amount of work of its kind without undue strain and wear upon any single one of its parts.

These elements had hitherto been wanting to the Continentals generally, but the display of this year, as compared with that of 1855, gives unmistakable proof of great progress in this direction during the period which has since intervened, and this is especially evidenced in the construction of machine tools, where much good workmanship may now be observed, and whose build assumes at length quite an English look. It is indeed only within the last five years that French makers seem to have understood that, in order to make a tool able to do both much work and good, a liberal weight of metal must be put into the tool. The same feature is observable in their locomotive engines, in whose details many good intentions and much good workmanship may be seen, although their general design will never be acceptable to English engineers.

Yourself, who make your observations with a discriminating eye, distinguishing between mere imitation and original thought, have consistently and, to my mind, very justly maintained that England still occupies the position of leader in mechanical industry, both in the matter of conception and workmanship; and from this fact you have drawn the conclusion that the fears spoken of were groundless, and that England still would remain the great emporium of mechanical industry.

The gloomy views entertained by others, however, have undoubtedly been greatly fostered by the recent achievement of a well-known French firm, whose works are situate in the very heart of that country, in furnishing one of our large railways with some forty or fifty locomotives at a price which, if it were not ruinous to the English maker, at any rate would leave him without a farthing of profit. Whether this is or is not an achievement accomplished in the mere pursuit of a French idea at a pecuniary loss (which, I am informed, would have been the case even if the Great Eastern had been perfectly solvent) appears to me a consideration of secondary importance, now that the inroad is made; for I believe the fact will remain present in the minds of many, especially abroad, and will be duly taken advantage of, that England has supplied itself with machinery from France; and it seems to me significant enough, conjointly with others mentioned, to justify inquiry into the reasonableness of those fears, and into the causes which may have brought about this state of things.

Now, the points to take into consideration in deciding upon a question of competition or comparison of cost, in the manufacture of any given article of trade, are:

1. The rate of wages of workmen, and their comparative abilities and worth;
2. The cost of the raw material; and
3. The management of works.

1. Granting the qualitative ability of Continental mechanics to be equal to that of the English, as has just been shown to be the case, it is a fact beyond dispute that the average wages of mechanical labour in England are at least one-third higher than on the Continent for ordinary day-work, and in some localities it is probably more than half as much again, because the difference between the wages of a skilled mechanic and a common labourer is much greater on the Continent than in England. Thus on the Continent the wages of a good mechanic may be as much as 6s., while a common labourer earns little better than 2s., showing a difference in the ratio of 3 to 1, whereas in England this ratio seldom exceeds 2 to 1. Then, again, the obnoxious rule of paying time and quarter (or more) for overtime, with its train of evil consequences, is totally unknown on the Continent, and thus in times of great pressure of work, overtime not only is no special source of extra expense, but, moreover, offers no special encouragement to studied neglect of duty, which is unfortunately too much the case in England in order to procure occasion for overtime for the sake only of the higher scale of wages which it yields. Besides this there is the item of walking time, which, in London at any rate, is made into an unyielding rule, and which is also claimed in northern towns in a more limited manner, of which the Continental employer knows no more than his own judgment commands him to concede, and which, in the run of time, causes the balance of expense to lean very much in his favour.

In these and other matters, such as the employment of apprentices and piecework, the English employer is absolutely at the mercy of the tyranny of trades' unions, who have greatly demoralised the English workman, and imbibed him with the nefarious notion that capital is the natural enemy of labour,

from which belief flows his unwillingness to do his very best for his employer; whereas on the Continent, notwithstanding that important concessions have been made to workmen on the subjects of strikes, the laws of master and servant are still very stringent and well defined; upon the whole, capital and labour work very harmoniously with each other, and live together on very amicable and even social terms. Much of the estrangement which exists between capital and labour, between employer and workman, in England, is no doubt due to the social system of the country, which thrusts the workman outside the pale of what is termed *respectable society*, on the simple ground of his being a workman; but the principal source of the great evils pointed out are undoubtedly the trades' unions as at present constituted, and until the English people relinquish some of their mistaken notions of freedom, and allow their Government to regulate the actions of these unions and to exercise a salutary supervision over them, these evils will increase rather than diminish, on the simple principle that the uneducated mind is more inclined to progress towards evil than towards good, when left to take its own course.

2. As to the cost of raw material (excluding Belgium from this comparison), pig iron certainly is still much higher in price on the Continent than in England, and the difference may be put down at a ratio of 3 to 2, in localities placed at great distances from the centres of production, which no doubt gives a great advantage to the English in those structures in which the weight of cast iron is the chief element of cost. The same difference, however, does not exist in manufactured iron, such as bars, plates, and joists, a fact well known to our manufacturers and engineering firms, since the former refuse to roll some descriptions of them, on the plea that they could not do it with any chance of fair profit, and the latter import and use them on the simple ground of cheapness; on the same ground, also, are Continental firms able to build wrought-iron bridges at as cheap and even a cheaper rate than English firms, and hence no work of this kind is now made in England for those parts of the Continent where French capital and French engineers are employed. Even locomotives are built successfully in a commercial sense, at and below the rate of 55*l.* per ton, tender included; whereas in England the cheapest rate does not reach as low as 60*l.* per ton, and this price does not seem to be over-remunerative, for I do not know that any of our modern locomotive builders have realised any very large fortunes.

In this question of cost of raw material, the price of coal necessarily figures as a very important item, and here it will become apparent that the late treaty of commerce with France has greatly assisted competition in those branches of manufacture in which coal is largely used; for steam and smithy coal, which some fifteen years ago cost 32*s.* per ton in remote localities, may now be had in those places at a lower price even than the manufacturer pays for it in London; whereas during the same period no material alteration has taken place in England; and although this reduction in price is no doubt accounted for to some extent by the greater comparative rate of production in France, still the treaty has done its share of the work, and it may fairly be pointed out here that free trade, which is a good thing in certain matters, is not necessarily of itself a universal specific for prosperity, and, like most good things, should only be made use of with moderation and discretion; for the French wines, which we get in exchange for our coal, will never change the habits of the mass of the English people in the matter of alcoholic drinks, and the ruin of the silk trade may yet be followed by a partial crippling of our engine factories. I am thoroughly convinced that later generations will reconsider this question of free trade in coal.

3. On the subject of management much might be said, but the gist of the matter under consideration resides chiefly in the two questions already examined. I would, however, observe that for the erection of large works, such as bridges, railway stations and roofs, lighthouses and works of like importance, England is wanting in that intelligent and well-educated staff which is formed in some of the Continental industrial schools; the practice with English firms is to place the work into the hands of mere workmen, which are believed to have some push in them, but whose untutored mind is never able to embrace the whole of the subject upon which he is engaged, with that comprehensive view taken by a mind which, through a long course of tuition, has been taught to think; and consequently it happens not unfrequently that many an undertaking, which had every appearance of becoming profitable while it was in course of construction, turns out a dead loss through unlooked-for expense in the course of erection. There are many estimable men in England who never will believe that a person is competent to superintend the execution of any kind of work unless he is an offspring of the bench, the fire, or the yard, and indeed the heads of English engineering firms are generally and thoroughly imbued with this idea.

These various considerations lead me to the conclusion that the fears spoken of in the opening paragraph of this letter are not entirely without foundation, and my apprehensions are by no means lessened when I reflect upon the fact that a few weeks ago only I found a large engineering firm, whose works are situated under the shadow of the Northern Alps, busily engaged upon an order of machine tools for China and Japan.

I remain, Sir,

Yours, very truly,

J. J. BIRCKELL.

Paris, October 8, 1867.

THE CLEVELAND IRON TRADE.—The make of pig for the quarter ending September 30 showed an increase upon the previous quarter of 10,133 tons, while there was a decrease in makers' stocks, notwithstanding the increase in the make, of 7242 tons. The demand for pig iron for Belgium and France, as compared with the shipments in the early part of the year, continues limited. In foundry work there is not much fresh business reported, although the various works are tolerably busy. The demand for rails continues steady, and it is said that a further large order for Holland has been placed in the district. The mills and forges are busy on this description of work, and heavy shipments will be made to Riga and Cronstadt until the navigations close. A large quantity of railway matériel is also being forwarded to Egypt.

FERRIES BETWEEN ENGLAND AND FRANCE.

TO THE EDITOR OF ENGINEERING.

SIR,—Not long since, I heard an American sea-captain say, that if the Straits of Dover and surroundings belonged to the United States, they would have had a proper ferry over twenty years ago, and I suppose it probable that there are not many Americans familiar with the case who do not believe it. Considering, then, that Europe contains ten times the population of the United States, and a similar area, it argues that there is ten times the want of adequate ferries over the Straits of Dover, particularly as the most densely inhabited and animated portion of Europe is within a radius of a thousand miles of the Channel.

I once thought it possible that frequent crossing of the Channel in the miserable cockle-shells used for conveying passengers would wear one into the notion that, after all, they afforded one of the boasted "solid English comforts." On the contrary, however, the late performance of my about fiftieth passage has not only increased my disgust, but stimulated an incentive to inquire, through the columns of your extensively read journal, where the much-needed ferry improvements have hitherto been urged, if the engineers of Great Britain are asleep. Is there none who understands the case, possessing a Brunel influence upon capitalists, to carry out one of the most profitable of enterprises, in fact, one that would probably afford a revenue to the London, Chatham and Dover, South-Eastern, and the corresponding railways of France, such as would prove acceptable?

The wants in the case are of a plain common-sense description. The London, Chatham and Dover and corresponding French lines should be connected by boats of 300 ft. to 500 ft. long, 60 ft. to 90 ft. wide, or the longer and wider the better, but in any case built very low, and not to draw more than 5 ft. or 6 ft. of water, bearing railway tracks, to carry in divisions any probable length of trains that would run between London and Paris, so that luggage or goods need not be disturbed between the place of departure and destination, or passengers leave their places, except for refreshments, preparations for which could be made on a grand scale and perfect system within the saloons, which should, from their spacious accommodation and adaptation to comfort, form an attractive feature of the boats. Ample accommodation could also be afforded for loaded teams or vehicles of all descriptions.

The wretched craft now plying between Newhaven and Dieppe should be substituted by boats of not less than 300 ft. in length and 50 ft. to 60 ft. wide, also low built, and drawing about 5 ft. of water, provided with no less comfortable and attractive accommodation than the former.

The railway trains should have trucks or cars for carrying luggage vans or crates on their own wheels, being run on to the former after they are packed with luggage, and on the arrival at Newhaven run off to a derrick on the shore and dropped to the deck of the boat; on arriving at Dieppe, lifted by another shore derrick, attached to horses, and trotted off to the train, where they would arrive as quickly as the passengers.

The greater portion of the cost of a properly contrived ferry would be the harbour arrangements, but no amount could be fairly invested in such an enterprise that would not yield a large remuneration.

When steamers connect with railways by sea or river in the United States, which is a very common thing, the boats arrive alongside a wharf in the usual manner, a wide gangway or bridge is swung by tackle suspended overhead and dropped on to the forward part of the boat. Horses, being ready, are hitched to the luggage crates, run rapidly to the train, and placed side by side on the truck intended for carrying them.

While this process is going on the passengers are moving off the aft part of the boat over a wide gangway, swung upon the boat in the manner aforesaid, and in a few minutes the train is off. So passages can be made any distance within railway travel, even to thousands of miles, and luggage not shifted on the way or seen by its owner until both are in the hotel or terminus forming their destination.

How is it between London and Paris? You first deliver your luggage at the station, where it is decorated, or rather soiled, with a label pasted upon it before it goes into the van; on arriving at Newhaven it is handled a second time on reaching the boat, a third time from the bridge of the boat to the deck, fourth, from deck to the hold, fifth, at Dieppe, from the hold to the deck, sixth, from deck to bridge, seventh, from bridge to shore, eighth, from shore to wagon, ninth, from wagon to the ground, tenth, from ground to the French van, eleventh, from van to customs, forming in reality about a dozen chances for "baggage smashing" on the way, besides the ridiculous waste of time in handling it.

And as to the boat we cross the Channel in!!

My last experience was in one of the "crack" or fast ones, a long, narrow, deep thing, skilfully modelled for pitching and rolling; the best and middle portion of the hull filled from side to side with boilers and machinery, leaving only the sharp ends which contain small holes dignified with the name of cabins, where, in stormy weather, which is not uncommon, the unfortunate passengers are packed, tossed, and sickened in a manner that extorts a promise not to try it again, and terrifies through evil report the millions from the first undertaking. In fact, except in the absence of the proper thing, such a boat has no commercial value unless for tugging ships about a harbour.

I need scarcely tell you, Mr. Editor, that if there are not engineers in England who understand the case, there are those out of it who are quite competent to furnish adequate plans for connecting the two sides of the Straits of Dover with a ferry that would probably encourage a traffic as superior to that enjoyed at present as the railway ever did over the slow coach.

British capitalists are always up to their work, and a plain comprehensive plan for a Channel ferry would be almost sure to meet with encouragement. Very respectfully,

T. S.

THE CHINESE COAST.—Preparations are being made for the erection of a complete system of lights and beacons along the Chinese coast. In all, fifteen points have been chosen.

ENGINEERS' TOOLS.

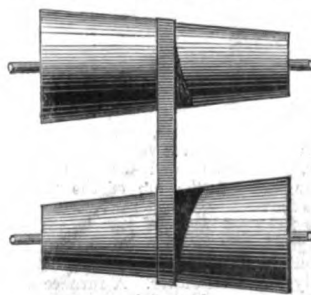
It is generally known that engineers' tools made in Scotland are somewhat different in their style and design from the tools made in the neighbourhood of Manchester and Leeds, the two great centres of machine-construction in England. Tool-makers in Scotland, who have principally to supply the extensive demands of marine engineers and shipbuilders in their own locality, are, by the nature of the heavy work for which their machines are intended, induced to look to great weights, massive framings, and very large castings in shape of foundations or base plates, rather than to that elegance of form and that economy of material which gives to the modern tools of the first tool-makers in Manchester or Leeds their style and characteristic appearance. There is, moreover, a great number of special tools used by marine engineers on the Clyde, and in many instances constructed in their own shops, which are different from those usually met with elsewhere, and which still further increase the difference in general appearance between an engineer's shop in Scotland and one in most other localities.

To commence with the lathe, we find it generally much broader in its bed, and fitted with larger spindles, stronger gearing, and a wider strap, than a lathe of the same height of centres is supplied with by English makers and by their Continental copyists. The hollow lathe—such as used by Mr. Penn, by the Messageries Impériales, by Messrs. Mazeline, in France, and by some other engineers—is not in use on the Clyde; but another kind of machine, resembling a lathe in its appearance, is employed apparently with much success. This machine has received the name of "devil," probably on account of its powerful action. The largest of its kind is at the engineering workshop of Messrs. Randolph, Elder, and Co., and a smaller one exists at Messrs. R. Napier and Son's shop at Glasgow. This machine is virtually a large-face lathe, having a great number of cutting tools fitted to the face-plate all round its outer circumference, the article to be operated upon being carried on a large bed in front of this face-plate in the same position in which the sliding carriage with the tool is placed in an ordinary surfacing lathe. The cutting-tools, following each other in rapid succession, operate upon the face of the article presented to them, and in their rotation take off shavings in circular segments, the tools being made to pass all over the surface by the straight movement of the article upon the bed placed in front of the lathe. To prevent the strain exerted upon the cutting-tools from bending back the face-plate at its periphery, a kind of backstay is provided behind the face-plate at the point where the cutting action takes place; this steadies the machine, prevents vibrations, and assists in producing a smooth surface. The face-plate of the machine at Messrs. Randolph, Elder and Co.'s works is about 12 ft. in diameter; the cutters are placed all round the circumference about 6 in. apart, and they are set to a gauge, so as to be all in one plane. They are held in their positions by set screws. The work performed by this machine is that of planing large surfaces, and this it does more quickly than the ordinary planing-machine; but it has the disadvantage, as compared with the latter, of being unable to plane a surface which has any projections around it, as these cannot be passed by the tools. It is also necessary to have the article to be faced very well stiffened behind the surface operated upon; otherwise the pressure of the tools will twist the surface at the ends, and it will be out of truth when finished. The same machine can be used as an ordinary face-lathe, by fitting a sliding carriage to the bed.

Another and a novel machine for facing large surfaces, particularly those of a circular form, such as cylinder covers, has been constructed by Messrs. Randolph, Elder, and Co. for their own use. This machine has a circular table placed in a horizontal position, this table being turned round a vertical spindle by means of a bevel-wheel fixed to the under side of the table, and geared into by a pinion on the driving-shaft, which is underneath the floor of the shop. The tools are three in number, each carried upon a slide similar to that of a planing-machine. These slides are supported at the ends by standards, and their position is such that they form the shape of the letter T in plan. The three arms leave one-half of the circular table free, and allow of fixing and removing articles of the same diameter as the table itself. The tools being set to the proper height, the work is performed by the table moving round its vertical axis, the feed motion carrying the tools to or from the centre upon the slides in radial lines.

The drilling-machines, in Scotch works, are mostly fitted with a pair of columns, or standards, which latter are placed sufficiently far asunder to admit the largest classes of articles. We, some time ago, gave engravings of a drilling-machine of this type, made by Messrs. Neilson Brothers, of Glasgow. The largest slotting-machine in Scotland, and probably the largest in the world, exists at Messrs. Robert Napier and Son's shop. This tool has a stroke of 4 ft. 6 in., and the slotting-bar works 7 ft. 2 in. clear from the standard. The bar is counterbalanced by a weight which passes through the hollow casting of the main standard, and is connected to the slotting-bar by a chain, which runs over a pulley at the top of the frame. The total height of this machine is about 25 ft., and the weight of iron contained in it is very nearly 100 tons. A smaller machine of the same kind, made by Messrs. G. and A. Harvey, is placed close to this machine, which was designed and made at Messrs. Napier's works, for their own use. The same works contain one of the largest planing-machines in existence. It was made by Messrs. Collier and Co., of Manchester, and can plane 30 ft. long, 10 ft. 6 in. wide, and 9 ft. deep. It carries four planing-tools, two on the cross-slide and one on each standard, and an extra standard has been fitted up at these works, and placed at the side of the planing-machine table, being fixed against a pillar. This is very useful for planing irregularly shaped articles of large size, which could not pass through between the standards. A very useful tool, of the character of a planing or slotting machine, has been designed and constructed by Messrs. W. and A. Inglis, of Glasgow, for their own engineers' shop. This is called a wall planing-machine, and consists of a long lathe bed placed on end and fixed to one of the side walls of the building in a vertical position. The guide-screw moves a plain carriage upon the bed, and to this carriage the planing or slotting tool is fixed. In front of the bed, and close to the wall, is fixed a solid foundation plate carrying a pair of slides and a circular table, which latter can be turned round by a worm, and moved in either direction in a straight line by means of the compound tables below. The work, which is fixed to the upper table, can, therefore, be brought into any required position in front of the tool, which latter finishes the surface by a series of parallel vertical cuts. The same principle is carried out in the well-designed machine at the Paris Exhibition, constructed by the Compagnie des Forges et Chantiers de l'Océan, the only difference being that the last-named machine is self-contained, and requires no additional support from the side walls of the building. A machine of a similar kind is also in use at Messrs. Penn's works at Greenwich.

A multiple drilling and boring machine of a peculiar kind, designed by Mr. Randolph, is at work in Messrs. Randolph, Elder and Co.'s shop for boring the frames of steam winches for ships, which are made in great number by this firm, and all are of the same pattern. The machine used for boring the two standards or frames of each winch has six horizontal drills placed in the same relative position which the bearings and boltholes occupy in these frames. The frames are first planed at the bottom and at one side, so as to fit against a kind of template formed by the base-plate of the boring-machine, and, being set against this template, all the holes are finished in their proper relative positions by the drills and boring-bars of the machine, which act simultaneously, being all geared to the same driving-wheel. A peculiar kind of cone-pulleys for the driving-belts of machinery is to be seen in almost every engineers' shop in Glasgow. This is a pair of wooden cones of great length, placed with their axes



parallel, and with their surfaces inclined in opposite directions. A belt being passed over these two pulleys, and transmitting the force from one to the other, it is possible to alter the relative speed of the two shafts by changing the position of the belt. This arrangement replaces the stepped-cone pulley more generally in use, and it has the advantage over the

latter of permitting smaller and more gradual changes of speeds to be effected. Against this, however, it has the disadvantage of being unsightly, and of occupying a large space at the side walls of the shop.

THE PHENIX FOUNDRY, GLASGOW.

To produce cast-iron water-pipes or gas-pipes at a selling price which is occasionally as low as 90s. per ton, while the average price of Scotch pig iron is from 55s. to 60s., and while engineers specify a test of the strength of the metal equal to a load of about 8 cwt. applied to the centre of an inch bar resting on supports 3 ft. apart, is a problem which may puzzle the ingenuity of many a manufacturer, and which, to judge from the prices of pipes in other countries, and from the high import duties maintained upon these articles in spite of all treaties of commerce, is one of extreme practical difficulty even at the present day. Notwithstanding this, however, it has been an accomplished fact in some of the Scotch foundries for a long time past. There is, indeed, so little margin left for the numerous operations which must of necessity be carried out in the conversion of pig iron into finished pipes, that only a system of manufacture conducted on a very large scale, and with special means for an economical production of moulds and cores, can succeed in attaining the required end.

The largest foundry in Scotland which makes pipe-casting one of the most important branches of trade is the Phoenix Foundry, Glasgow, carried on under the firm of Messrs. Thomas Edington and Sons, although no partner of that name has been in this business for a long time past. The Phoenix Foundry consists of three distinct and separated foundries, each devoted to a special kind of work. The total establishment covers an area of nearly six acres, contains fourteen cupolas with an aggregate power of production reaching about 300 tons per day, and the actual production of one year's work has amounted to 56,360 tons of finished castings. The three foundries are placed close together, and divided only by the main roads and thoroughfares of the locality; but the division of labour between them is such that very little, if any, interchange of articles takes place; and a distinct set of men is employed in each for their special kinds of work. The foundry for railway chairs and cast-iron sleepers forms one of these distinct and self-contained departments. It consists of a large set of sheds containing four cupolas, each capable of melting from 50 to 60 tons of iron per day. These cupolas are destined for alternate working in pairs. The blast is provided by a fan 10 ft. in diameter, worked by a 30 horse power horizontal engine, which drives two belts, each working a pulley at one end of the central shaft of the fan. The iron charged in the cupolas is a mixture of three or four different brands of Scotch pigs of average quality, which are charged with a proportion of 3 cwt. of good coke to the ton of iron, and with a very small addition of limestone as a flux. Common railway chairs are moulded by hand in the usual way; but the moulding of cast-iron sleepers is to a great extent done by some of Jowitt's patent moulding-machines, working in a manner similar to that described in our columns on some previous occasions. The Phoenix Foundry has acquired the exclusive right of manufacturing in Scotland Griffin's patent iron permanent way, which is now coming into extensive use on some foreign lines of railway. There is at the present moment a considerable quantity of Griffin's sleepers for a railway in Spain and for a line in South America in course of manufacture. The chair and sleeper foundry, if employed to its full power, can cast 100 tons of sleepers per day.

The most remarkable department is that devoted to the manufacture of large pipes. The power of production in this special foundry is equal to 100 tons of castings per day, and it contains four cupolas of equal size to those of the chair foundry. The largest pipes cast in this department are 4 ft. in diameter and 9 ft. in length; these have been supplied to the Loch Katrine Waterworks. Each length of these pipes weighs 3½ tons, and their length has been reduced below the limits of size of the moulding machinery in the foundry, in order to keep down the weights of each single piece and to facilitate transport. The smallest pipes made in this department and moulded by machinery are 6 in. in diameter, but pipes have been cast in the Phoenix Foundry down to ½ in. in diameter, and pipes of this size can be made at a sufficiently low price to compete with wrought-iron or lead pipes with considerable advantage. The

moulding of pipes consists of two distinct operations, each of which is carried out at the Phoenix Foundry by special machinery and apparatus invented at these works. These operations are the ramming of the mould and the preparation of the core. The moulds are made in cast-iron moulding-boxes, built up in lengths and properly turned and centred at all the flanges, so as to afford a sufficient facility for correct and accurate moulding. The larger moulds are each mounted upon a four-wheeled truck; the smaller moulds are placed together in pairs, or in groups of four, upon a similar truck, and these trucks are moved throughout the foundry upon rails running all over the ground. The natural formation of the locality has afforded the possibility of arranging this foundry upon two superposed levels, one raised about 20 ft. above the other; and this has been taken advantage of for constructing two large circular pits of about 60 ft. in diameter each, the bottoms of these pits being level with the lower foundry yard, while the upper level upon which the cupola is placed is the working platform of the foundry. The two pits are open at one side, to allow of the introduction of the moulds and their removal from the pits by means of the trucks and rails before mentioned. The transportation of these large and heavy articles is therefore very conveniently effected, and is reduced to a slow traverse over a very limited area. At one side of each of the two circular pits is a house containing the moulding-machines. The moulds are brought under the machines upon the rails, and thence transported into the foundry. After casting they are removed into the yard, emptied, and prepared for use again, so that in their use they describe a kind of circle laid out in the arrangement of rails on the ground. The moulding-machines are some of the most ingenious contrivances existing in modern mechanism. They were patented several years ago, but have since been altered in many of their details. We regret that we are not in a position to publish drawings or a very complete description of these interesting machines; but their general principles will be understood from the following: The moulding-machine works with a skeleton pattern, *i.e.*, with a short piece of a cylinder equal in diameter to the outside diameter of the pipe, but only a few inches in length. This is inserted centrally into the mould at the bottom, leaving a space of some 3 in. all round, to be filled with sand and rammed up. The ramming is done by a series of steel bars suspended from a frame, and surrounding the pattern, so as to form a circle of projecting fingers all round the latter. The ramrod or bar to which these fingers are attached is hollow, and a second rod connected to the pattern passes through its centre. The movements of the ramrod and pattern are all self-acting, and mutually dependent upon each other, the pattern being drawn up slowly and steadily in a straight line, while the ramming takes place by a series of strokes combined with a rotary movement given to the circle of steel bars. The operation is most effective, quick, and uniform. A pipe of some 3 ft. in diameter and 12 ft. in length is moulded in about four minutes, complete, and ready for the insertion of the core. Smaller pipes are moulded by similar machines, and the speed of working can be changed to suit the size of work. The moulding by these machines is much more uniform and reliable than hand-work, and its saving in time and cost is one of the main advantages possessed by these works.

An operation of equal importance to the moulding of the pipe is the construction of the core. This, too, is carried on in a special manner. The cores are made of a layer of loam and straw, surrounding a cast-iron body, which is made in pieces and held together by stays. These latter are movable, and can be loosened after the pipe is cast. The interior of the core is thereby made to collapse, and the iron skeleton can be removed from the centre of the core, the rest being cleared out of the pipe in the usual way. There are four pipe-moulding machines at work in this foundry. They are placed close to the drying-stoves, and these latter form the passages from the moulding-house to the foundry-pit. Each pipe, when cast, is tested by water pressure, and five testing-machines are for this purpose distributed throughout the foundry, so as to facilitate testing and save transport of pipes. The machines are hydraulic presses with their tables placed vertically, and the columns in a horizontal position. The pipes are inserted endways between the two parallel tables, one of which is movable, and can be brought to bear against the end of the pipe by means of five screws, all geared together, so as to press the table forward in a straight line. The pipe is first filled with water from a reservoir, by opening a valve, which must be shut after filling the pipe. Pressure is then exerted by means

of a hand-pump, and a weighted lever acting upon a safety-valve regulates the pressure. The testing pressure is occasionally specified in the contracts; but even without such a prescription each pipe made at these works is tested, the usual pressure being equal to a head of 600 ft. of water. The arrangement of the foundry is such, that each pipe, in passing from the foundry-pit to the store or doors, must cross the testing-machine. After testing, the pipes are dipped into a trough containing a paint or varnish, patented by Dr. Angus Smith many years ago, and now in very general use in the foundries of Scotland. It is a composition of tar, resin, naphtha, mixed in such proportions as to be easily kept at a temperature of about 400 deg. without evaporation or decomposition taking place. The liquid mass is constantly kept at this temperature, and the pipes are dipped into it cold, and allowed to remain for about twenty minutes, so as to acquire the temperature of the bath very gradually. This has been found preferable to heating the pipes previous to the dipping process, as the varnish unites more closely with the surface of the metal, and remains very firmly attached to it after cooling.

Of the various other operations followed in preparing and finishing pipes and other articles made in this foundry we shall give an account in our next number.

AMERICAN RAILWAY CARS.

Two magnificent day cars, the "Forest City" and "Garden City," have lately been started to run between Chicago and Cleveland by the Michigan Southern and Northern Indiana Railroad Company. These two cars are exactly alike in their construction, and the following description of the "Forest City" given by the *Syracuse Journal* will therefore apply to both of them. Respecting the "Forest City" it says:

"It is without doubt the most magnificent car of its class that has ever been placed upon any railroad in this country. The exterior appearance of the car is unique, being painted in a *cuir* colour, handsomely striped with gilt. In the centre, on either side, is an oval indenture, in which is handsomely painted the name 'Forest City.' The running gear of the car consists of two six-wheel trucks. The length of the car inside is 56 ft., width 10 ft. 3 in., and height 10 ft. At either end is a door leading into the car, and also a blind door. On entering the car at either end, to the left is a passage-way, 2 ft. in width, leading to the central parlour of the car. The whole car is divided into five commodious and roomy compartments, each one of which is capable of being made completely private by its inmates by means of sliding wooden doors. On entering the car, immediately behind the door is a conveniently fitted up water-closet, between which and the first compartment is ample room for the placing of a stove for heating the car in cold weather. Passing to the left a few feet, you enter the first compartment or parlour, which is 6 ft. by 8 ft. in size, with a passage-way leading from the door to the large plate-glass window in the side. On either side of the room is a handsomely covered sofa, or *tête-à-tête*, one end of which is so constructed as to be movable, making a perfect chair. A small table is attached to the side of the car by movable fastenings, and admits of being placed into the centre of the room; and as the movable portions of the sofas are opposite ends, the arrangement for the enjoyment of a social game of cards becomes perfect. Next in order, as you pass towards the centre of the car, is a compartment, larger in size than the first one, but fitted up in precisely the same manner. Still going toward the centre of the car, we next find a narrow compartment extending entirely across the car, with doors on both sides, in which, on either side, is a finely fitted up toilet arrangement, the upper portion of which shoves back into the centre of the car, and beneath is a convenient water-closet for the accommodation of lady-passengers. The narrow compartment is entirely separated from the other compartments by a sliding-door. From this compartment one steps into the central saloon of the car. This saloon is 10 ft. by 11 ft. in size, and is provided with two *tête-à-têtes*, two easy chairs, two small round-seated chairs, and a centre table. The chairs are movable, and can be placed in any position by the passenger. The *tête-à-têtes* are fastened at either end of the saloon. Above the latter articles are placed splendid mirrors. On each side are two racks of what-nots for the accommodation of all hand baggage of passengers. Either side is also provided with two half-round side-tables for the accommodation of water, &c. The arrangements of the compartments from the door to the central saloon are the same in either end. The sofas, *tête-à-têtes*, and chairs in the various apartments are handsomely carved in rosewood, and are tastily upholstered in purple, green, blue, silver, and yellow French morocco. On the ends of the various apartments are newspaper racks, in which will be found the principal papers of the day, for the use of the passengers. The arrangements for ventilation are perfect, on the sides being placed, every 2 ft., Kirby's patent adjustable ventilators, while the longitudinal section of the roof is provided with Creamer's ventilators. The arrangements for heating this car are equally well looked after. A furnace will be placed at either end, and in the sides of the car are pipes conducting hot air to every apartment, the temperature of which can be regulated by registers let into the sides of the car. The interior finish of the car is made of several varieties of wood, among which we noticed black ash, birch, satin, black walnut, rosewood, mahogany, curled maple, birds'-eye maple, cherry, ebony, holly, and laurel, all finished in the natural colour of the wood, and highly polished and decorated with gilt. The sides and ends of the various rooms are constructed of these different woods handsomely inlaid, and on the panels of the

ends are inlaid monograms of the "M.S. & N.I.R.R." Above these monograms are handsome carved medallions, carved from black walnut. The floors of the various rooms are covered with splendid Axminster carpets, and each room is provided with spittoons, &c., bearing the name "Forest City." The apartments are capable of accommodating from six to sixteen passengers. The main saloon is provided with a plate-glass window on either side, 40 in. x 42 in. in size, while those of the other rooms are somewhat smaller. The "Forest City," together with its mate, the "Garden City," were constructed at the car shops of the Michigan Southern Railroad, and both cars are designed to run between Cleveland and Chicago, commencing on the 23rd of September last. These cars were built under the supervision of Mr. John Kirby, master builder at the Michigan Southern Railroad car shops at Adrian, Michigan, and we are compelled to admit that the taste displayed in the getting up of these cars excels anything we have ever seen. The cost of these cars reaches the sum over \$25,000 each."

Cars equally magnificent are also being put upon other American lines, and two more new palace cars, of the superb Pullman pattern, have just been completed at the car shops of the Canada Great Western Railway, at Hamilton, and were recently exhibited at Detroit. One is named "The President," and the other "The Vice-Royal." They are similar in their interior arrangements to the "Western World," "New York," and "City of Boston," which have been running through from Chicago to Rochester for several months past. Their exterior appearance, however, differs materially from those, the Hamilton cars being painted a beautiful claret colour striped with gold. Upon each side of the car are two medallions, representing "Morning" and "Evening," which are tastefully executed and beautifully bronzed. The cars are of the same dimensions as those previously spoken of, are calculated as dining-room or hotel cars, having a cook-room at one end, where edibles can be prepared and served up to passengers. Each car contains four state-rooms, and accommodates about fifty passengers. These cars, with the four similar cars now running from Chicago to Rochester, will run continuously from Chicago to Albany. They form an admirable acquisition to the Pullman line of palace cars.

THE ATLANTIC TELEGRAPH.—After a considerable amount of negotiation between the Atlantic Telegraph, the Anglo-American, and the New York and Newfoundland companies, the basis of an agreement has been come to for a reduction of the present tariff of charges. The assent of the New York and Newfoundland Company has not yet been obtained to some of the minor details, but the proposed reduction has received the assent of all the parties interested. It is proposed to reduce the present charge of 10*l.* to 5*l.* for a message of ten words, giving five words, not exceeding twenty-five letters, for the name and address of the sender and receiver of the message. All extra charges for code messages are to be abolished, the rate being the same as for ordinary business. The companies, however, reserve to themselves the right of declining to send any particular form of code which may be offered to them. For any word over and above ten, and five for name and address, the charge will be 7*s.* 6*d.* The reduction is to take effect on the 1st of November, and provision is made in the agreement for a further revision of the tariff, and return to original rates if the receipts during the current three months do not reach a certain specified sum.—*Railway News.*

RAILWAYS IN NEW JERSEY.—A meeting of railroad managers, in New Jersey, U.S., has resolved that no further attempts be made to control the action of the Legislature in behalf of existing monopolies, those companies being satisfied with the position they have already attained, and having come to the conclusion that the money required for political uses can be more profitably employed in improving and extending their lines, and in increasing their dividends. It was further resolved that the rates of fare be fixed at *two cents per mile* on all trains, and for all distances within the State; that commutation tickets be furnished at reasonable rates, and the use of such tickets be encouraged; that the express system be assumed by the several companies, and that the policy of the several companies be to encourage the development of local enterprise and improvement throughout the State.

THE CLEVELAND IRON TRADE.—There is not much change to notice in the Cleveland pig-iron trade. The operations of the last few days show, if anything, rather more activity. The stock of pig in the warrant stores is 73,317 tons. Some of the foundries are tolerably well off for orders for the winter, while others are only partially provided with work. Large quantities of railway castings for Egypt and India are being shipped; but, on the whole, there appears to be less activity than usual among founders. The engine works of the neighbourhood are not very busy. The plate and bar iron trades look somewhat better, although prices are still comparatively unremunerative. Large deliveries of rails for Russia, Egypt, and the colonies are still being made, and the various mills and forges are rather better employed than they have been for some time past.

BELGIUM.—The imports of English pig iron into Belgium continue, and they are, in fact, increasing, having attained a total to August 31 this year of 34,765 tons, as compared with 17,442 tons in the corresponding period of 1866. Spain has ceased to take any Belgian rails, in consequence of the almost complete collapse of the Spanish railway interest. In the first eight months of this year, however, 56,045 tons of Belgian rails were forwarded to Russia, and 5538 tons to Italy.

ENGLISH TENDERS IN BELGIUM.—An adjudication has just taken place at Brussels, for various articles required in connexion with the Belgian State railways. Two lots of 240 each of Bessemer steel axles for carriages and wagons provoked a tender from the Barrow Hematite Steel Company, and another from John Brown and Co. (Limited), Sheffield. The lowest tender, however, was that of MM. Goffin, of Clabecq. The tender of John Brown and Co. (Limited) was rather higher than that of the Barrow Hematite Steel Company. John Brown and Co. (Limited) also tendered for pistons for the buffers of goods trucks; the lowest tender, however, was that of MM. Bassilière, Daviensart and Co., of Molenbeek St. Jean.

RECENT PATENTS.

THE following specifications of completed patents are all dated within the year 1867; and that year should be given in ordering them, at the annexed prices, from the Great Seal Patent Office, Chancery-lane.

(No. 338, 10d.) Andrew Betts Brown, of the Vauxhall Ironworks, Wandsworth-road, patents a form of portable drilling-machine, intended to be used in cases in which, from the weight of the object to be drilled, it is better to move the drilling-machine to the work than the work to the drill. The machine is driven by a small engine directly attached to it, the engine being supplied with steam by a flexible pipe.

(No. 341, 8d.) John Sherman Hoar, of the State of Massachusetts, U.S., patents various forms of bench-vices, which could not be clearly described without reference to drawings.

(No. 342, 2s. 4d.) John Ramsbottom, of Crewe, patents various useful appliances for lifting, supporting, moving, and forging heavy masses of metal. One of Mr. Ramsbottom's improvements is a method of lifting ingots out of a furnace by means of tongs attached to a counterbalanced arm, which is bent over the furnace so that the point of suspension is directly over the ingot to be raised. The patent also includes a simple form of turntable for facilitating the handling of ingots; carriages for transporting ingots, and for holding them whilst being subjected to the action of the duplex hammer; and an arrangement for cutting discs off ingots by means of cutting edges fixed to the duplex hammer-heads. This specification will be of considerable interest to those engaged in the production of heavy forgings. We illustrate some of its details on the next page.

(No. 343, 1s. 4d.) William George Beattie, of South Bank, Surbiton, patents various forms of piston-slide valves for locomotive and other engines.

(No. 347, 10d.) William Thomas Carrington, of Perth, patents an arrangement of steam road-roller, also applicable as a traction-engine. The main feature in the roller is that it is carried on three wheels or rollers, two of the rollers being placed on the same axle, with a space between them, and the other being arranged centrally, so that it acts upon those portions of the road left between the pair first mentioned. The single roller acts as the steering wheel, and it is made in two portions to facilitate turning. This arrangement of wheels for a steam road-roller was patented in December, 1863, by Mr. William Clark and Mr. W. Fothergill Batho (see patent, No. 3216, A.D. 1863).

(No. 359, 1s. 6d.) Arthur Ormsby, of 19, Parliament-street, patents a method of collecting and storing rain-water by means of an extensive area of roofing, covered with glass, or some other non-porous substance, and furnished with the necessary pipes for conveying the collected water to a distributing reservoir.

(No. 361, 1s. 4d.) Henry Allason Fletcher, of the Lowca Engine Works, near Whitehaven, patents a combined boring and planing machine, this machine being so arranged that a locomotive cylinder, or similar piece of work, placed on it can be bored and planed simultaneously, and will thus only require setting once.

(No. 362, 1s. 6d.) John Henry Johnson, of 47, Lincoln's-inn-fields, patents, as the agent of Auguste Arban and the Marquis Marie Joseph Antoine Ernest de Lagrange, of Paris, an arrangement of propeller consisting of series of floats fixed to beams, the ends of which are carried by cranks revolving vertically at the sides of the vessel. There are to be several beams on each side of the ship, the cranks working them being placed at an angle to each other. The motion of each beam is of course similar to that of the coupling-rod of a locomotive engine, and the floats attached to it are forced through the water during the lower half of each revolution of the cranks, and raised clear of it during the upper half of the revolution, when they perform their return stroke. There are many obvious objections to this form of propeller, and it is, moreover, very far from being new.

(No. 365, 10d.) William Jones, of Wolverhampton, patents machinery for making elbows, T-joints, sockets, &c., for joining gas and water pipes. This machinery consists of arrangements applied to a steam hammer, so that the movements of the head of the latter are communicated to dies which close in sideways upon the article to be forged, and to mandrils which enter the article so as to form internal supports. The article is also acted upon by swages carried by the hammer-head and anvil.

(No. 269, 1s. 10d.) George Daws, of Penge, patents an apparatus for effecting the opening and

closing of railway crossing-gates by the action of the passing trains. The practicability of the arrangement is more than doubtful.

(No. 376, 8d.) Robert James, of Poole, patents improvements in Cornish boilers, these consisting in placing within the boiler flue what may be described as a smaller Cornish boiler, also provided with the usual internal flue or flues. The inner boiler is connected with the water spaces above and below the main flue by water-passages. The internal boiler only occupies that portion of the main flue beyond the bridge, and the heated gases pass through the flue or flues of the inner boiler, and also through the annular space between the latter and the main flue.

(No. 377, 10d.) Charles William Dixon, of Wickham Market, patents the elastic railway wheels described on page 407 of our third volume.

(No. 385, 4d.) William Edward Newton, of 66, Chancery-lane, patents, as the agent of Benjamin Chew Tilghman, of Philadelphia, U.S., treating fibrous vegetable substances with a solution of sulphurous acid in water, with or without the addition of sulphates, at a temperature not exceeding 212°, the object being to extract the cellular matter, and leave the fibres in a state in which they can be easily separated and made available for paper-making and other purposes.

(No. 386, 1s. 10d.) John Ramsbottom, of Crewe, patents an arrangement for effecting the rapid transfer of locomotives or carriages from one line of rails to another. The apparatus, which is specially applicable for adding additional carriages when these are required to make up a departure train, consists, according to one arrangement, of one or more pairs of rails, corresponding to those of the permanent way, attached to endless chains, which extend transversely across the line of the railway, and are passed over chain-wheels placed beneath the surface of the ground. The chain-wheels can have motion communicated to them by steam or hydraulic power, and the rails carried by the chains slide on beams or girders. We illustrate this arrangement on another page.

(No. 387, 8d.) Edward Manico, of Bedford-street, Strand, patents forming the foundations of sea-walls, breakwaters, and similar works of a series of cradles constructed of light iron bars disposed in a lattice form, these cradles being partially filled with rough stones, and containing brushwood, which assists in the retention in the cradles of sand and shingle deposited by tidal action.

(No. 389, 10d.) Eugene Henri Bernier, of Rue Corbeau, Paris, patents an arrangement of hoisting apparatus specially intended for raising or lowering heavy loads. In this apparatus, the main hoisting chain is led over a pulley at the top of the scaffolding down to a pair of chain pinions, over which it is passed in opposite directions. These pinions are turned by the crab gearing in opposite directions, and it is by them that the hauling power is exerted on the chain, there being no winding drum, as in ordinary winches. The free portion of the chain, after leaving the chain pinion, is led under a weighted stretching pulley, and again attached to the weight to be raised. One of the main features in the arrangement is the use of an auxiliary or safety chain to prevent the falling of the load in the event of the main chain breaking. This safety chain is led over pulleys at the top of the scaffold, one end of the chain being attached to the load, and the other end carrying a weight by which the chain is continually kept tight as the load rises. At the top of the scaffolding the safety chain passes under a series of detents, these detents holding the safety chain, and sustaining the load in the event of the main chain failing.

(No. 394, 4d.) William Henry Towers, of New York, patents a method of manufacturing a material which he names "coribu," by immersing new hides in a bath of boiling sulphur. It is stated that the "coribu" so formed is, when dried, hard and transparent, and that it can be moulded into the various articles now made of vulcanite.

(No. 397, 10d.) Henry Houldsworth Grierson, of Manchester, and John McElroy, of Sale, patent some arrangements of steam-engine governors in which the arms by which the balls are carried are fitted with links so as to constitute a parallel motion, the balls being thus made to diverge in a plane at right angles to the shaft by which they are driven. The centrifugal action is resisted by a spring acted upon through an arrangement which could scarcely be clearly described without reference to drawings.

(No. 400, 10d.) Joseph Westwood, of Tredegar House, Bow, and Robert Baillie, of Leyton, patent improvements in iron safes and doors. One point

claimed is making one of the vertical sides and top and bottom of the opening with a series of steps or ledges, against which the door fits, the object being to prevent the insertion of wedges. This plan is far from new. Another claim is for constructing safes with an internal case, the latter being capable of turning on pivots and being fixed with its door at the back of the internal case; and a third point is the construction of doors so that they can be turned on a centre, and fixed by bringing ears or lugs on the door over the inside of the safe or other fixture to which the door is fitted. We are doubtful whether either of these latter are new proposals.

(No. 401, 8d.) Joseph Westwood, of Tredegar House, and Robert Baillie, of Leyton, also patent methods of connecting the various lengths of iron piles and columns. According to these plans, one of each pair of lengths to be joined together is provided with internal dovetailed projections, which pass down between corresponding dovetailed projections formed in the interior of the adjoining length. By turning one of the lengths partially round, the two sets of dovetailed projections are caused to interlock, and an effectual connexion is thus formed between the two lengths, whilst the exterior of the pile or column is left free from projections or inequalities of any kind. In some cases, however, the dovetailed pieces may be arranged externally, if preferred.

(No. 402, 1s.) William Gedge, of 11, Wellington-street, Strand, patents, as the agent of John Lochhead and Charles Arthur Mathieu, of San Francisco, California, various arrangements of water-tube boilers, which we could scarcely describe without reference to drawings.

(No. 403, 1s.) William Clark, of 53, Chancery-lane, patents, as the agent of Emery Ross Gard, of Chicago, machinery for pressing and moulding bricks. This machinery is provided with a rotary mould-block, having openings, or moulds, in which are placed followers worked by means of an annular way having an undulating surface, the followers being provided with hinged lids, which are raised for the purpose of discharging the clay. A particular arrangement of striking plates and the combination of the whole machinery are also claimed.

(No. 405, 8d.) Samuel Dwight Mack, of New York, patents machinery for cleaning wheat and other grain. In this machinery, the separation of the smut, garlic, &c., from the wheat is effected partially by the adhesion of the substances to be removed to the surfaces of soft rollers against which the grain is pressed by a central rotating cylinder, and partly by the action of a fan or blower. The impurities adhering to the cleaning rollers are removed from the latter by suitable brushes.

(No. 410, 2s.) John Thomson, of Ardwick, Manchester, patents machinery for finishing screw-nuts, facing the heads of bolts, polishing the grooves of the winding-on scrolls used in spinning-mules, and polishing the grooves and circumferences of pulleys. The various machines included in this patent could not be clearly described without reference to drawings.

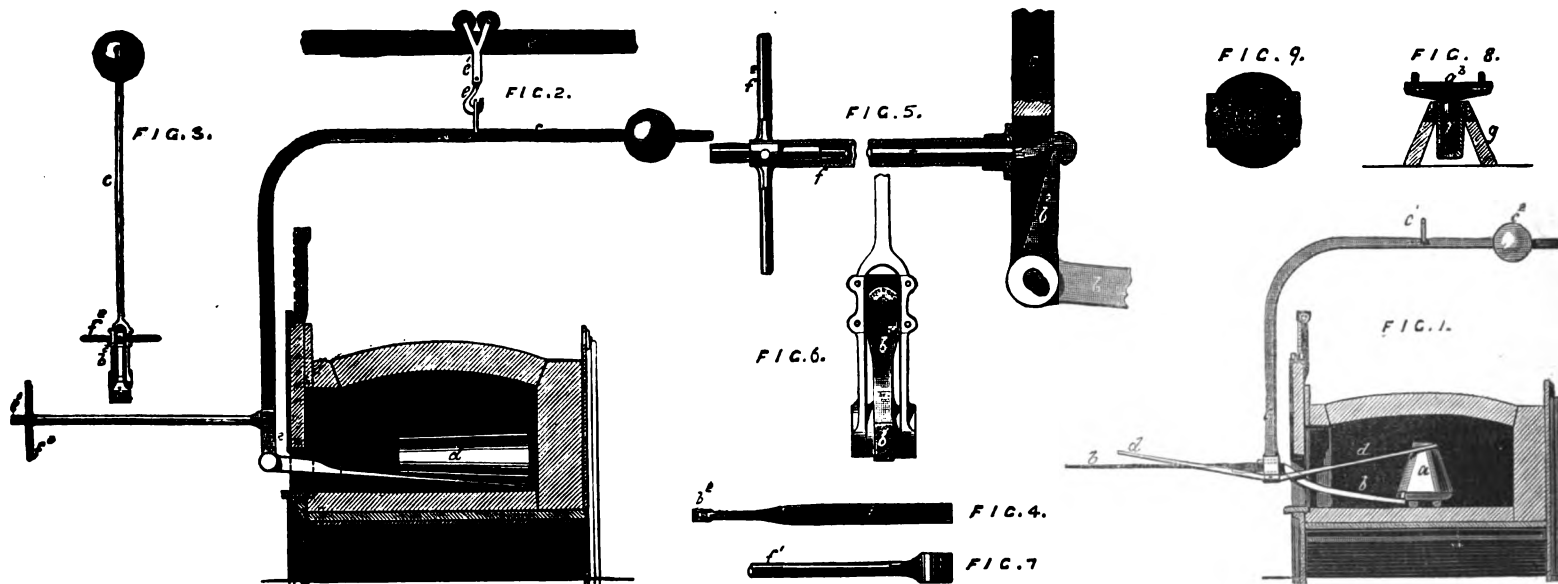
(No. 429, 8d.) Alfred Vincent Newton, of 66, Chancery-lane, patents, as the agent of Robert Westcott and Job Symmes Crane, of Elisabeth, New Jersey, U.S., a form of water-meter, consisting of two double-acting measuring cylinders, each provided with a piston and with an ordinary slide-valve. The pistons are connected to cranks, placed at right angles to each other on a crank-shaft extending across the top of the cylinders, this shaft also carrying the eccentrics by which the slide-valves are worked. The whole arrangement, in fact, is similar to that of a direct-acting engine. The number of revolutions made by the crank-shaft are shown by a counter.

(No. 438, 10d.) Richard Hodgson, of West Ham, patents an arrangement of self-acting feed for punching-machines. According to these plans, the punch is rendered movable horizontally, and is caused to work in a slot or guide placed in a proper relative position to the die. After a hole has been punched, the punch, before rising again, traverses along its slot a regulated distance, and drags the plate, or other object being punched, with it; the distance thus traversed being regulated by stops according to the pitch of holes required. The punch then rises, moves back horizontally into its original position, and descends to make another hole. This apparatus is somewhat complicated, and we do not see that it possesses any advantage over the more simple contrivances at present in use for effecting the same end.

(No. 440, 1s. 10d.) Robinson Thwaites and Edward Hamer Carbutt, of Bradford, and John Sturgeon, of Burley, near Leeds, patent arrangements of

INGOT-LIFTING APPARATUS.

DESIGNED BY MR. JOHN RAMSBOTTOM, LONDON AND NORTH-WESTERN RAILWAY, CREWE.



steam-hammers, in which the "tup," or hammer-head, is made in the form of a cross-beam, the ends of which are connected to pistons working in a pair of steam cylinders, placed one on each side of the arvil-block. The principle of the arrangement is similar to that of Messrs. Chatwood and Sturgeon's hammer, which we illustrated on page 679 of our last volume.

(No. 452, 8d.) Henry Young Darracott Scott, Lieutenant-Colonel, R.E., of Ealing, patents a method of constructing concrete floors. According to this plan, the ordinary joists are dispensed with, and, instead of them, tie rods extending from wall to wall—or, in the case of wide spans, from girder to girder—are employed. The tie rods, which are placed at intervals of from 2 ft. to 3 ft., are well bonded into the walls, or secured to the girders, as the case may be, and upon them the concrete is carried, the bonding of the mass together being in some cases assisted by interlacing hoop iron or strong wire with the bars. In this arrangement it is intended that the tie rods and hoop iron should take the tensile strain, whilst the compressive strain is resisted by the concrete, which acts as a strut to keep the wall or girders apart.

LITERATURE.

The Mining and Metallurgy of Gold and Silver. By JOHN A. PHILLIPS, Mining Engineer. London: E. and F. N. Spon. 1867.

In one sense the above title is inaccurate, for the book contains something less than its title, and a great deal more. Of the mining proper of gold there is very little, because the getting of gold soils is a very easy matter; and as to the mining of silver proper, it is like other mining. It has evidently been Mr. Phillips's object to give us a complete treatise on the metallurgic productions of gold and silver, a plan in which he has succeeded; but if he had devoted his space to mining proper, he must have sacrificed the value of his work as a special technical manual. Mining in this treatment is fuller. It gives us all the geology and topography of gold and silver ores in an admirable manner, suited to our more educated knowledge of the subject, and free from the crudities of scientific and unscientific men. It takes up the treatment of gold just at the point where excavating or mining ceases, and where what may be called the real operations begin. Thus his account of the great works in the chief districts of California, compiled from professional documents, and illustrated by his own observations on the spot, enable the practical man to follow out the whole subject.

The same mode is followed for silver, and every variety of reduction processes is adequately described by one who has seen them at work. It is one great advantage of this book that it is not the production of an adventurer, shifting about from country to country, and giving us the results of his chance-experience eked out by compiling from other writers. The volume before us is produced by another kind of man, and by another process. It is the composition of a professional man, and is the natural offspring of his professional

labour. Forty years ago, if we had sought an authority on such a subject, it would have been a German. Between him and a Cornish mine-captain we should have had no choice. Now, by the operation of events, we must seek among English and Americans the chief practitioners. The gold and silver mining companies born from the speculations of 1825, gave us our first opportunities in these branches of metallurgy, and the discovery of the gold countries in the possession of the English race, Virginia, California, Australia, New Zealand, and English Columbia, have enabled us to apply this experience extensively. Silver metallurgy, developed in our lead mines, at Swansea and at Newcastle, in California and Nevada, has given us scope in a specialty formerly confined to Spaniards and Germans. These advantages, with those we already possessed on both sides of the Atlantic in iron, coal, copper, and tin metallurgy, have constituted a great national school of mining and metallurgy. The greater development of scientific instruction has put us on the same par in that respect as our neighbours, while we now exceed the Germans, Spaniards, and Russians in every branch of practice; and as to the French, their highly developed education has little chance of application.

It is under these circumstances that the English mining engineer has open to him the practice of the world, and it is standing in this high position that Mr. Phillips has visited so many countries for practical and professional purposes under favourable auspices, that he has acquired the materials, and been able to put them together in such a shape as to constitute a standard treatise on what is now a very important branch of industry.

For metallurgic purposes the ores must be crushed, and this process, essentially mechanical, requires the knowledge of a mechanic, which Mr. Phillips is able to bring to bear upon it. Thus we have fully depicted a ten-stamp battery, the Grass Valley rifle apparatus, the machinery employed at Schemnitz, and that at Morro Velho, in the Brazils. While these are illustrated by working drawings, others are described, and minor apparatus and details are given in wood engravings. Of these there are near upon a hundred.

Amalgamation, smelting, and assaying are distinctly chemical processes, and these demand treatment by a competent hand. Mr. Phillips has brought these up to the latest date, and in giving recent improvements he has exercised the necessary discretion as to what is safe and accepted and what is doubtful.

The want of such a book was great. German and French books can seldom be well employed, except by a man who has been trained on the Continent, while what we require is a knowledge of what is being carried out in our countries, and treated in our own language. We are not surprised that Mr. Phillips's book was at once eagerly taken up, but it will be long before the many distant purchasers will be able to ascertain what they have got for their money. Those who have sent them the volume have done so for good reasons. A practical man can at once see that he has got what he wants in the mass, and, seeing the care bestowed on the treatment, he can trust Mr. Phillips's reputation for the details.

APPARATUS FOR HANDLING INGOTS.

MR. JOHN RAMSBOTTOM, of Crewe, has recently patented a number of useful contrivances intended to facilitate the handling of heavy ingots, and of some of these we annex illustrations. In our engravings, Figs. 1, 2, 3, and 4 show two forms of ingot-lifting apparatus, whilst Figs. 5, 6, and 7 show the details of one of these appliances drawn to a larger scale; and Figs. 8 and 9 represent a simple form of turntable on which an ingot can be turned.

In Fig. 1 the lifting-apparatus is shown, as applied to lifting one of the conical ingots used by Mr. Ramsbottom for manufacturing steel tyres. In this figure the conical ingot, *a*, is supported by the paddle, *b*, which is attached to a counterbalanced arm, *c*. This arm is bent over the top of the furnace, and the crane-chain is attached to it at a point, *c'*, directly over the centre of gravity of the arm and ingot. The adjustable weight, *c''*, serves to balance the arm, *c*, and the prolonged end, *b'*, of the paddle, this prolonged end being used by the operator for moving and guiding the ingot. The ingot is held on the paddle, *b*, by the bridle, *d*, which is hinged to the lower end of the arm, *c*. The advantage of this arrangement is that the weight usually employed to balance the ingot is dispensed with, and a considerable saving of time and mechanical labour is effected, as the weight of the ingot being completely borne by the crane, the operator has only to control its position.

Figs. 2, 3, 4, 5, 6, and 7 refer to another form of lifting apparatus, especially adapted for use with furnaces which are not provided with cranes. In this instance the counterbalanced arm, *c*, is suspended from the hook, *e*, which is hinged to a frame, *e'*, running on the fixed rail, *e''*, placed above the furnace, and about in a line with its centre. The paddle, *b*, is hinged to the lower end of the arm, *c*, and it has the arm, *b'*, forged in one piece with it. To the lower end of the arm, *c*, is fixed the tube, *f*, through which passes the rod, *f'*, one end of which is screwed, and the other hooked. The hooked end of this rod takes hold of the upper end of the arm, *b'*, and the other or screwed end is provided with a cross handle, *f''*, the nave of which forms a nut fitting the screw. By turning this handle round in the proper direction, the paddle, *b*, is brought up to the under side of the ingot, and the latter lifted clear of the block on which it rests, and it can thus be brought out of the furnace, or shifted as desired.

The portable turntable, shown in Figs. 8 and 9, is intended to be placed near the mouth of the furnace in which the ingot or other article has been or is to be heated. The turntable consists of a conical stand, *g*, in which is fitted a socket, *g'*, supporting the spindle, *g''*. This spindle carries a plate, *g'''*, provided with studs on which the ingot bears, these studs being of such weight that they hold the bottom of the ingot clear of the plate, *g'''*, and allow the paddle to be placed beneath it. This turntable, which may, if desired, be mounted upon wheels, is found useful for enabling the ingots to be readily turned either before they are placed in the furnace or after their removal from it.

J. F. CAIL AND Co.—This important French mechanical company makes up its accounts on June 30th, in each year. The current exercise (1867-8) commenced with orders on hand to the amount of about 156,000*l.*; and during July, August, and September, further orders were received to the amount of 184,000*l.* The operations in which the concern is engaged in connexion with the Kiew and Balta will not be carried through until 1869. A participation of work exists between the concern and the Fives-Lille Company.

SOUTH YORKSHIRE.—There is a fair business doing at most of the ironworks of this district. There are said to be some large orders on hand for rails, principally for home requirements. The coal trade is moderately active. A fair tonnage—principally of engine-fuel—is being forwarded by the Manchester, Sheffield, and Lincolnshire Railway to the Lancashire cotton districts. At Sheffield there is an improved demand for some descriptions of railway materials; but, upon the whole, this branch of business is not very brisk. At the Yorkshire locomotive works the men are on full time.

THE RIVER DON STEEL WORKS.

STEEL is only iron, in its best and most valuable form. The chemists once considered that it was a definite chemical compound of iron and carbon, and named it carburet of iron, and Dr. Thomson believed that this contained twenty equivalents of iron to one of carbon; but we now know that we may have steel of a very wide range of carburisation, and that (as absolutely pure iron is unknown), all irons, whether wrought iron, cast iron, or "steel," are equally carburets of iron, so long as the carbon is not graphitic. Steel, as we continue to call it, is not more distinctive from other forms of iron than are wrought iron and cast iron from each other; yet it is the only form of iron which is at once fusible and malleable, and it possesses, besides, the peculiar property of being greatly hardened by being heated and then plunged into water. It is not unlikely that, for nearly all purposes of construction, cast iron and wrought iron will yet become obsolete materials, and useful only for conversion into the best kind of iron, viz., "steel." And it may yet happen that we shall drop the almost meaningless term "steel," and call it "iron" only. Cast iron might then be described as crude iron or raw iron, and wrought iron as rotten iron or burnt iron, as it really is—its valuable constituent, carbon, being burnt out to an injurious extent in the toilsome and, indeed, barbarous operation of "puddling." Not alone in tensile strength, but in ductility or toughness, steel is now as much better than the best wrought iron as the latter is better than cast iron; and steel has the further advantage that it is manageable in castings or forgings of any weight, where, on the one hand, cast iron would be too brittle and too weak, and wrought iron unsafe from the danger of unsound welds and internal crystallisation.

Of late years iron, whether known by that name or as "steel," has been—growing in strength and adaptability, and it has thus attained qualities which would have been incredible twenty years ago. We now have castings, forgings, rolled bars, rails, wire, &c., made of "steel," which are, beyond all comparison, stronger and tougher than iron in any other form ever known before. It is this wonderful growth of iron, so far as its useful qualities are concerned, that has made the metallurgy of steel so popular among non-professional men, thousands of whom are now nearly as well-informed upon it as upon those more engrossing questions of ordnance and armour, upon which at least half of all the reading men in the kingdom now hold definite opinions. Bessemer's wonderful discovery turned general attention to the philosophy of iron-making, and to the beautiful combinations of which iron is capable, and it is now well understood that there are other and not less beautiful analyses and syntheses to be discovered, which will yet give to iron an intrinsic value not only greater than that of gold and silver, but far beyond anything now known of the best steel. The great secret of iron-cultivation, if we may employ such a term, is that of crystallisation, and this cannot long elude the grasp of the genius of metallurgy; and when we can once control the size, form, and arrangement of the crystals of iron, in all its stages of conversion, we shall have made it, in effect, a new metal.

Steel castings, made to pattern, were unknown until within the last few years; and although they are now largely and successfully produced, the art of making them is still practically confined to two establishments—one that of the Bochum Company, in Westphalia, the other the River Don Steel Works, Sheffield. The casting of very hard steel into objects of simple form presents no remarkable difficulty, inasmuch as these may be run into iron moulds, and their soundness may be insured by "feeding" the casting, after pouring, in the same manner as with ordinary iron castings in the foundry. It is an object, however, of very great importance that the steel should be the softest possible, so far as the term "soft" is understood by steel-makers. It should not have more than from $\frac{3}{4}$ to 1 per cent. of carbon, whereas very hard steel contains $1\frac{1}{2}$ per cent. Although the harder steels have very great tensile strength, they are brittle, like cutlery steel, and it has indeed been the great difficulty, in the old processes of steel-making, to get rid of this characteristic brittleness by lessening the proportion of carbon. The smaller the proportion of carbon, the greater the heat at which the steel will melt, and the greater the difficulties in casting it, soundly, to complicated shapes, or indeed to any shape at all. Wrought iron contains the least carbon, say one-fourth per cent. of its own weight; and cast iron contains most, or from $2\frac{1}{2}$ to 7 per cent. Between these we have steel ranging in carbon fr-

$\frac{3}{4}$ to 2 per cent., the steel rails, of which so many are now used, containing about $\frac{1}{2}$ per cent., mild steel castings $\frac{3}{4}$ per cent., and hard cutlery steel from $1\frac{1}{4}$ to $1\frac{1}{2}$ per cent. The proportion of carbon, upon which the quality of the steel wholly depends, requires nice chemical analyses for its exact determination, although it can be somewhat nearly ascertained by the colour of a solution of the steel in acid, every proportion of carbon giving its own shade of brown. But a still better test is that of the specific gravity of the steel. As carbon is lighter than iron, the greater the hardness of the steel, the less its specific weight. The purest irons have a specific gravity of about 7.895, while steel rails, as now made, have about 7.855; and the harder steels are still lighter, merely, of course, because of their greater proportion of the lighter material, carbon. The harder steels have the finest grain, and we are apt, therefore, to speak of them as being more "dense" than ordinary bar iron; but the fact is that they weigh less, and are therefore less dense in the true meaning of the term.

As steel is intermediate, in its proportion of carbon, between cast iron and wrought iron, it may be made, as by the Bessemer process, by depriving cast iron of a portion of its carbon, or, as in the processes more commonly followed, by adding a certain proportion of carbon to wrought iron. The latter may be done either by the old process of "cementation," which is that of roasting bars of iron, packed in charcoal, for a fortnight together in an air-tight furnace; or by the better and cheaper process of melting wrought iron, cut into scraps, along with charcoal and oxide of manganese, in a melting-pot, a mode of converting iron into steel first pointed out, early in the present century, by David Mushet. The old malt-kiln-looking converting-furnaces are being gradually abandoned, and the best Sheffield works now melt down the wrought iron direct. At the River Don Steel Works of Vickers, Sons and Co. there are 288 melting-holes, capable of taking, each, two pots of either 60 lb. or 100 lb., and 40 tons of Swedish and English bar iron are often melted down in a single day.

The quality of the steel made by any process whatever depends greatly upon its proportion of carbon, and also upon the character of its crystals, which are not altogether dependent upon this proportion, but upon the purity or otherwise of the iron used in making the steel. And it is the fact that the purest materials crystallise in the largest crystals, like frozen rain into snow-flakes, or like the finest samples of sugar, which have always a larger crystal than the inferior kinds. When converted into steel, a very pure iron, unmixed with any other substance, will give a large crystal, and, if broken suddenly across, a coarse fracture; and while it is most important to keep out certain impurities, like sulphur and phosphorus, the addition of manganese appears to alter the crystallisation to a much finer degree, and thus to give a finer fracture when broken suddenly; for almost any bar iron or steel will show a fine fracture, if broken gradually. As every iron-founder is well aware, a mixture of irons is stronger than almost any single sample, and the same fact unquestionably holds good in steel-making, even the purest Swedish iron being improved in the strength of the steel made from it by being mixed with other irons in the melting-pot.

By melting a mixture of various bar irons along with a regulated quantity of charcoal and manganese, steel of almost any desired quality may be produced. Were there no charcoal (carbon) present, the iron would be nearly or quite infusible; and the less the charcoal, the greater the difficulty of fusion, and of casting into sound pieces or "goods." The less charcoal, too, the less the absolute tensile strength, but the greater the toughness; and it is better to lose something in strength at a dead pull, in order to avoid brittleness, and thus to secure toughness.

We have thus sought to sketch out roughly something of the philosophy of steel, in order that the splendid and, indeed, astonishing results now achieved in steel-founding may be the better understood. The casting of twenty-two railway wheels upon a single stalk, and of a locomotive cylinder all in soft steel, could not have been credited twenty nor even ten years ago, yet these are exhibited at Paris by the Bochum Company; and Vickers's great works, at Sheffield, could reproduce them, if required.

The first great requisite in steel-founding is that of a sufficiently refractory moulding material. Although steel, like cast iron, is not "chilled" by being run into iron moulds, it would obviously be very costly to use iron moulds for a great variety of steel castings, and iron would have the disadvantage also of causing too sudden cooling on the outside, whereby the casting would often be injured in strength. A German

steel-founder, Riepe, who was the patentee also, in this country, of the art of making puddled steel, patented, about fourteen years ago, the employment of a material for steel-moulding, which should be infusible and invitrifiable by reason of its having been already subjected to a heat greater than that of melted steel. Such a material is calcined fire-clay, and this is best obtained by breaking and grinding the old melting-pots, as these last for but two or three meltings, and are then otherwise useless. This material, mixed with just sufficient fresh fire-clay to render it plastic, is now used for steel-moulding, a thickness of perhaps $\frac{3}{4}$ in. being applied over the pattern, and the box then rammed with ordinary sand.

Another requisite for steel-founding, and more particularly in soft steel, is that the melting-pots should be more than usually refractory, as the great heat of soft steel melting destroys ordinary and even Stourbridge clay-pots in one or two meltings. Messrs. Vickers, Sons and Co. employ a special mixture for their pots or crucibles, into which plumbago enters with manifest advantage. Crucibles made wholly of plumbago are not used, only because of the belief that they give up a portion of their carbon to the steel, and thus alter its quality. Even if this opinion be well founded, it is certain that for all other melting operations plumbago crucibles are the best, and their adoption for steel-melting may yet be found possible and advantageous. The crucibles made at the River Don Works are formed wholly by machinery, at the rate of 1000 a day, and are dried, in thirty days, at a temperature above that of boiling water, so as to drive off all moisture. The drying-house is large enough to contain 30,000 pots, so that even if 1000 a day were wanted, enough would always be ready. The pots are of two sizes, to hold 60 lb. and 100 lb. of steel respectively, and with 288 melting-holes 576 suffice for the three meltings each day, the pots being then broken up.

The contraction of steel for each degree of temperature is practically no greater than that of iron, but as steel sets at a much higher temperature, its contraction, after setting, is greater, because of the greater range of temperature through which it must cool. This great contraction, which is greater as the steel is softer, is apt to cause the formation of cavities within the casting, or, rather, of a single cavity known as a "pipe," and locomotive crank-axes, when improperly made, have been known to be "piped" for 4 ft. of their length. To prevent piping, soft steel castings require a large "head," and this is, indeed, so large that in small castings it often amounts to nearly the weight of the casting itself. The "piping" in this case will go on rather in the "head" than in the casting, and even then the head must be fed with more steel, from time to time, after the casting has been poured, and the "feeding" thus amounts sometimes to nearly 10 per cent. of the weight of the casting. Only large "heads" and timely "feeding" can prevent—and they effectually prevent—hollowness in steel castings.

Finally, after casting steel to pattern, and not for subsequent forging, it should be annealed, and allowed a week or so to cool.

Such are the general principles and precautions which have enabled the proprietors of the River Don Works to make large and complicated castings in soft steel, representing, most important branch of national industry, and affording new and most valuable resources to the mechanical engineer.

The River Don Works were founded by the old firm of Sanderson and Naylor, which afterwards became Naylor, Vickers and Co., and is now Vickers, Sons and Co. (Limited). Within the last two or three years large new works have been erected at Brightside, near Sheffield, and the old works have been sold. The new works, employing 1000 men, and extending for nearly a quarter of a mile along the Midland Railway, are among the most convenient and complete in their arrangement and mechanical appliances of any works, constructed for any purpose, in the kingdom. Besides offices, warehouses, model-rooms, stables, &c., the works are divided into five large and separate masses of buildings, viz.—1st, that for cutting and mixing the iron for conversion, and for making, drying, and storing the pots; 2nd, the melting-house, with three-quarters of an acre under a single roof; 3rd, the moulding-house and iron-foundry; 4th, tyre-mill, smith's shop, and machine shop; and 5th, steam-hammer shop. These buildings are connected in all their parts by railways of both the common and 2 ft. gauges, and there is about a mile of sidings belonging to the works, and in connexion with the Midland Railway. A tank locomotive, by Hawthorn and Co., of Leith, runs upon the various lines and around curves of 60 ft., or less

than one chain radius, the engine having 3 ft. coupled wheels, spaced only 5 ft. apart centres. The railway system is carried out, indeed, in the works to a remarkable extent. The melting-house has cellars beneath it, and nearly all castings of considerable weight, with the exception of tyre ingots, are cast in boxes mounted upon railway trucks, running upon lines below. One of the large annealing furnaces, standing, too, out of doors, has its hearth and door formed upon a railway truck, and the locomotive takes this hearth away with it to the casting-house, and returns with the casting to be annealed, backing the furnace-bottom with the large furnace-door into its proper place in the brickwork of the furnace itself. So complete is the railway system within the works, that but seven horses are employed, where sixteen were worked at the old establishment within the town of Sheffield.

The hoisting apparatus is, if possible, still more complete. A horizontal pumping-engine, with a double-acting pump, 7 in. in diameter and 30 in. stroke, draws water from the river through a 12 in. main, 1200 ft. long, and with a lift of 20 ft., a vacuum vessel being placed near the pump to lessen the shock of this column of water when stopped at each stroke. This pump forces the water through a 10 in. main half a mile long, to a reservoir upon a hill at that distance and 240 ft. above the pump. This reservoir, with its embankment, occupies an acre of ground, and can be filled to a depth of 20 ft., and gives a pressure of water of 110 lb. to the square inch at the works. At this pressure the water enters the steam-boilers without any other boiler-feeding apparatus, and it works the hydraulic cranes, of which there are seventeen in the works. These cranes are of great simplicity, and Mr. Edward Reynolds, the engineer of the works, has promised us drawings of them for illustration. These cranes are not only applied to the ordinary purposes of lifting and traversing weights, but in the tyre-mill they are made to assist in charging the ingots or rings into the furnaces, and drawing them out when heated ready for the rolling-mill. A somewhat similar plan of landing furnace-piles and blooms is now in course of adoption at Dowlais, and it deserves to be introduced into all forges and rolling-mills. The water-pressure from the reservoir is applied in various other ways of considerable ingenuity. A blowing-fan was required in one of the houses where there was no engine to drive it. Instead of putting down an engine therefore, and incurring the cost of its attendance, the North Moor Foundry Company were commissioned to make a small turbine and a Schile's fan, the former to be driven from the water under pressure, and which has an effluent velocity, after allowing for losses, of about 80 ft. per second, or nearly a mile a minute. Another application of the water-pressure is still more ingenious. In the tyre-mill the water thrown upon the tyres in rolling finds its way into the fly-wheel pit, which is 14 ft. deep, and which has no outlet drain. To lift out this water a jet-pump or ejector is used, and this is formed like the sucking end of Giffard's injector. An $\frac{1}{2}$ in. jet of water, under the pressure from the reservoir, or 110 lb. to the inch, is discharged within, and in the direction of a tapering nozzle of 2 in. or 3 in. diameter. The action of the jet causes a vacuum and raises the water from the fly-wheel pit, and discharges it where it can drain properly away. The useful effect obtained is very fair, $\frac{3}{4}$ gallons a minute under a head of 240 ft. raising, besides itself, 37 gallons per minute from a depth of 14 ft., thus giving a ratio of useful effect of $\frac{3}{37 \times 14} = 7\frac{1}{2}$ per cent., nearly. Mr. Reynolds, who designed this elegant apparatus, has kindly promised us a drawing of it for publication.

The bar iron is assorted and cut up at one end of the works by three or four pairs of shearing-machines, each worked by an independent engine. These machines were made by Davy Brothers, of Sheffield, and cut each two bars at a cut, at each end, into pieces of about 1 lb. weight, and these are afterwards cleaned of all oxide, dirt, &c., in revolving cylinders or "rumbles." The pot-making, which we have already noticed, goes on in an adjoining building.

The melting-house, built so as to admit of future extension, is 200 ft. by 150 ft. inside, the roof being made in 50 ft. bays, and supported by but four pairs of double columns in addition to the walls. It is of the utmost importance in a melting-house where large castings are to be made that every man has a clear view from his melting-hole to the place of casting, and the foreman founder should be able, in the same way, to see, from a single point, every melting-hole from which steel is to be brought for teeming. The melting-house at the River Don Works is in this respect

perfect, and, by an almost military organisation of the workmen, a single casting of 25 tons weight may be poured from 576 pots, holding 100 lb. each, within the space of five minutes, or at the rate of one pot every half-second. The pots are carried upon small barrows which admit of the workman tipping the pot without changing hands.

The melting-holes are lined, as usual, with ganister to a considerable thickness, and this has to be renewed, on an average, once a month, the heat being about the most intense known in the arts. $2\frac{1}{2}$ tons of coke are burnt in melting a ton of steel, whereas a ton of iron would melt with 2 cwt. of coke, or $\frac{1}{12}$ th the quantity. The melting-holes are ranged in eight rows, communicating with as many chimneys, by means of a large underground flue to each row. The chimneys are each 100 ft. high, and 7 ft. square in the inside, which is smooth and parallel all the way up. This large sectional area, with the regulated admission of air to the melting-holes, insures a slow rate of ascent to the gases, and thus a strong draught; for strength of draught is best secured, where the escaping gases are at a high temperature, by a large chimney in proportion to the quantity of gases entering it. The ascensional power of the gases is thus always in excess of the rate of admission, and they rise but slowly, merely because no more than a certain quantity of gases can enter the chimney within a given time to follow them up. The chimneys and the flues leading to them are, of course, lined with fire-brick, and the chimneys are bound outside with stout iron bands at short distances apart, and even these have been found no stronger than necessary to resist the expansion of the brickwork under the great heat.

Ingots for tyres are teemed, as solid cylinders, into cast-iron moulds ranged along the floor. It was once the custom to cast tyres as rings. Formed in this way, they required to have a "head," often of $2\frac{1}{2}$ cwt., or nearly equal to the weight of a carriage tyre, and this head had to be smithed off, at a considerable cost for labour, and afterwards broken up and remelted. If the ring was cast in an iron mould, it tore itself open by unequal contraction, the inside remaining fluid after the outside had set; and if cast in a fire-clay mould, the contraction was still irregular, and ten per cent. of all tyre castings were "wasters." Now that tyres are cast in solid cylinders, a little coned at the top, no head is required, and the ingot is teemed into a plain iron mould, and no wasters are ever made, nor do these ingots require feeding to prevent "piping," inasmuch as the centre is punched out under the hammer before forming the tyre. Castings made to pattern are run into moulds placed, as already described, upon railway trucks beneath the casting floor. These castings of course have large heads as a security against "piping," and they are "fed" with a very considerable amount of steel after being poured, to compensate for their contraction.

A large branch of the steel founding department of the River Don Works is that of casting steel crossings for railways. Although sold at a higher price per hundredweight than cast iron, they are far lighter for the same strength, and they are furthermore made reversible; so that, as with a double-headed rail, a fresh face may be turned up after its fellow has been worn out. The immense superiority of these crossings over those of any other material has created a wide demand for them upon railways throughout the kingdom and in America. In Messrs. Vickers's model-rooms there are upwards of 25000 worth of patterns for steel crossings alone. Some of these, made to meet special cases, as those for the Metropolitan Railway, are 19 ft. 6 in. long, or longer than what, but a very few years ago, was the standard length of a rail. The strength of these crossings is incomparably greater than that of chilled iron, the tensile strength of the steel of which they are made being 32 tons per square inch, while their hardness is equal, or nearly so, to that of the best chilled iron, and they do not "chip" in use. We have carefully examined some of these crossings, which have been for more than two years in use near large junction and terminal stations, and we have found the wear very light indeed, and no signs of chipping, even at the point. These crossings were undoubtedly good for two years more on the same face, and they can then be turned and used four years more upon the opposite face. It is nearly certain, from the number and character of the railway companies who have already adopted these crossings, that no other kind will long continue to be used.

The civil engineer and engineering architect will find much in the roofs of Messrs. Vickers's works to please him. In the melting-house are plate girders of 50 ft. span, made up of single lengths of angle iron

and top and bottom flange iron. We hope yet to publish sections of these girders, as well as of others about the works worthy of attention. In the tyre-mill the 60 ft. beams, intended to carry the steam-traveller, were rolled in one length at the Butterley Works. These are not at all the heaviest beams rolled there; and after a close inspection of all the deep narrow-flanged girders, exhibited at Paris by the Commeny and Chatillon Company and other French makers, we risk nothing in saying that no mill on the Continent can turn out girders to compare with the splendid broad-flanged beams rolled by Mr. Alleyne, at Butterley.

All cast steel is improved by hammering. Steel castings, made to complicated patterns, or, indeed, to any pattern, cannot be hammered, however, and the value of hammering is reserved therefore for ingots intended for "shapes," as for tyres, shafts, &c. A very large portion of the business of the River Don Works consists in forging and rolling steel ingots to shape. The chief branch of this business is that of railway tyres. These are cast, solid, in iron moulds, placed along the floor of the melting-house. The ingots must be as carefully as possible poured to weight, and weighed afterwards, so that there shall be hardly ten ounces difference between a dozen tyre blanks intended for the same engines or carriages.

The tyre ingots go into the steam-hammer shop, where they are heated and flattened into "cheeses," and then punched through under the hammer at the same heat. The heaviest hammer, by Thwaites and Carbutt, of Bradford, has a head of 15 tons, with 30 tons of steam pressure in addition (with 60 lb. steam) upon the top of the piston. The punching process is now common with all steel tyre "cheeses," or flattened ingots. It removes any unsound or "piped" portion of the casting at the centre, and opens the way for further rolling. Until Mr. Thomas E. Vickers's improvement upon the tyre-mill, illustrated in *ENGINEERING* of September 28, 1866 (vol. ii., p. 228), these cheeses required to be hammered out on the beak iron of an anvil in order to adapt them to the rolling-mill, of which no example could take a tyre ingot as punched by the steam-hammer with a 9 in. or 10 in. hole. The collars upon the rolls required to be so large that only an ingot well opened out could be slipped over them, and this is yet the case with all tyre-rolling mills except at the River Don Works, where, however, Peter Rothwell Jackson's mill is still retained for *finishing* tyres. The saving of a single heat upon an ingot, and of the expense which attends all steam-hammering, is an important one, and, when everything is taken into account, we are disposed to believe that this costs not much less than 4s. per ton, or 4s. per cwt. At the River Don Works, the ingot is heated, and then flattened and punched at one operation, as usual. The punched ring is again heated and rolled into a finished tyre at the rate of one every nine minutes, and we have ourselves watched the rolling of seventeen large driving-wheel tyres, weighing 930 lb. each, in two hours and a half. With the exception therefore of the heat of the original melting in the crucibles, the material of a tyre is heated but twice, whereas at every other tyre works in the kingdom three heats are required, and of course at an increased cost. Mr. Vickers's patent mill is used only for "breaking down" or roughing out the tyre, and this it accomplishes in from half a minute to a minute, according to the size of the tyre and the tyre then goes, at the same heat, to the Jackson mill, where it is rolled truly to size within a short space of time.

Mr. Vickers's rolling-mill is the only one in which the outer and the inner rolls are driven by separate engines. The inner roll is purposely made small, to take on an ingot punched with but a small hole, and it has not therefore sufficient adhesion of its own, and requires independent power. The outer roll is driven by a pair of overhead engines, designed by Mr. Reynolds, and having 24 in. cylinders and 3 ft. stroke, while the inner roll is driven by a similar pair, except that their dimensions are exactly one-third smaller, being 16 in. cylinders and 2 ft. stroke. With all its appliances of hydraulic tackle for hauling the ingot from the furnace, hydraulic cranes for lifting, &c., this is the most effective and convenient tyre-mill in existence.

The Jackson tyre-mill is driven through large and high-speed spur-gearing cast upon Mr. Jackson's system of moulding, and we have never seen large and fast running wheels working more silently.

The machine-shop in which tyres are turned and bored (when this is required), wheels and axles fitted, links cut out and turned, &c., is of large size, and contains many modern tools of a type representing

the great difference in engineers' tool practice as applied to steel and iron respectively. In all operations by cutting tools, Messrs. Vickers make it a point to take heavy cuts, and this can only be done upon steel by tools of great hardness and durability. Steel for such tools is made by Messrs. Vickers themselves, and is known as "special steel," and it is beyond comparison the finest tool steel produced. It is made chiefly for their own use, but it is also sold, at 1s. per pound, or 112l. per ton, and none who have once tried it will now have any other. We saw it reducing the diameter of a large steel shaft one inch at a cut, feeding ten cuts per inch, with a surface speed of 9 ft. per minute, and at this rate the tool requires grinding but once in three hours.

For these tremendous cuts in a material so hard as cast steel, the lathes, planing-machines, &c., are necessarily of great strength, and while the speed of the work is slow, the speed at which the driving-belts are run is high, the motion being brought down by treble instead of the ordinary double gearing. As engineers are now going largely into the use of steel, as many as possible should examine the tools provided by the steel-makers themselves for working it. The best tools at the River Don Works were made by Smith and Coventry, of Manchester, some, however, being made by Sharp, Stewart, and Co. Although the working speed, or rate of cut, is so much slower than in iron, the requisite strength is much greater, and this is provided by very heavy beds, strong spindles, large bearings, &c. For steel it is probable that all lathes above 12 in. centres must be treble-gear, as there is a great advantage in running belts at a good speed and correspondingly low tension, thereby preventing slipping. One of the lathes, copied from a German (Bochum) pattern, is driven by a stout worm and worm-wheel. This lathe is employed mainly for cutting off the heads of castings. Among the great number of large lathes is one for boring and turning driving-wheels and tyres, and which can be employed also for polishing the bosses of driving-wheels. The ordinary working speed of the lathe and the speed for polishing bosses differ so greatly that lathes for the same purposes had been previously made with two cone pulleys, and separate gearing to each. Mr. Reynolds decided, however, to have a lathe of this kind with but a single cone pulley, of four speeds, and he managed the polishing motion by a very simple arrangement of the gearing, throwing out one pinion and throwing in another. It is not easy to make this clear without a drawing, but tool-makers as well as many mechanical engineers will fully understand the point of what we say. Messrs. Sharp, Stewart and Co. made this lathe, to Mr. Reynolds's design, and we observe that they exhibit a similar lathe at Paris, which has been well spoken of by many engineers.

In taking heavy cuts in planing steel, the carriage of the planing-machine is apt to be forced sideways; Mr. Reynolds therefore ordered a planing-machine of Messrs. Smith and Coventry, which has no V's, but only flat sliding surfaces, with the vertical faces of the bed trued and grasped by bearing pieces on the carriage. This is an excellent machine, not only for its steadiness in working, but it can stand any side cut whatever.

The River Don Works are unique. There are other, although few, establishments in England which make steel castings; but there are none which make so many, so heavy, and so intricate castings in soft tough steel. There are none which make so many nor, we believe, so good crucible steel tyres. Vickers's tyres, or, as they have been for a few years known, Naylor, Vickers's steel tyres, are in great favour on the London and North-Western Railway, and on other leading lines, where they are found to be not only cheaper, but better than Krupp's, which were at one time as soft as iron, and hardly stronger. In America Vickers's tyres are widely used, and their value is freely acknowledged. The cast-steel crossings are even more generally adopted, and it is now well understood that the permanent-way accounts of no line can be kept at their proper figure without them. Besides these, cast-steel axle-boxes, horn blocks, &c., for locomotives, are now known to be far better, and, in the end, much cheaper than iron, and steel is being largely used for these purposes. Cast-steel crank-axles are, of course, beyond all question better than iron, and they are now largely, although not entirely, used. It is not long since, when the blocks of steel crank-throws were slotted out with a 1½ in. groove on each side, they could be broken out by wedging once or twice to each side. Now, steel cranks have been so toughened that it requires from five to seven of these wedgings through a range of 2½ in. to break them out. We need not further describe the arrangement, machinery, and appliances of the River Don Works; for what has

been given is sufficient to show, that while they occupy a distinct and exclusive field of production of iron in its best form, viz., steel, they are among the most complete and mechanically perfect in the kingdom, and possess appliances which enable them to produce the higher qualities of crucible steel goods at less cost than other works.

TRACTION RESISTANCES ON RAILWAYS.

(Continued from page 375.)

Influence of the Size of the Bearings upon the Axle-Friction.

In the case of the wagons, the average area of the rubbing surface of each axle-bearing was 188 square centimetres (29.14 square inches); whilst in the case of the engines upon which the experiments were tried, it amounted to 452 square centimetres (70.06 square inches). Now it was found that the values of f^w were:

For wagons	$f^w = 0.018$
For engines	$f^w = 0.053$

and it is thus seen that the coefficient of friction is greatly increased with the increase in the area of rubbing surface.

It is therefore an advantage, as far as the traction resistances are concerned, to reduce the area of the rubbing surfaces to a minimum; but it is necessary to give the axles journals of sufficient size to prevent seizing, as well as to ensure their not breaking down under their load.

This double consideration, the desirability of reducing the size, whilst maintaining the strength of the axles, leads to making the latter of steel, and there can be no doubt about the advantage of using Bessemer steel, which is softer than cast steel, and stronger than iron.

Influence of Temperature on the Resistances.

The authors have drawn up two comparative tables—the first including all trains tried at a low temperature (0° to -3° Centigrade = 32° to 23.6° Fah.), and the second comprising those trains on which the experiments were made during a higher temperature (+15° to +20° Centigrade = 59° to 68° Fah.). The circumstances under which the two sets of trains were tried were, except as regards the temperature, alike; and of the axle boxes of the trains, 90 per cent. were lubricated with grease. The coefficients were found to be:

	Coefficients of Resistance.
	kilogrammes per tonne.
At the low temperatures ...	5.22 = 11.7
" " high " " " "	3.47 = 7.77

Thus, at temperatures approaching freezing, the traction resistance was, with grease axle-boxes, increased 50 per cent. With boxes lubricated with oil, on the contrary, the influence of temperature was not observable.

Influence of Inclines on the Resistance.

The authors have drawn up several comparative tables, including

- Trains tried on a level;
- Trains tried on rising gradients of from 1 to 5 millimetres per metre (= 1 in 1000 to 1 in 200);
- Trains tried on rising gradients of 5 to 10 millimetres per metre, &c., up to 17 millimetres per metre (= inclines of 1 in 200 to 1 in 100, &c., up to 1 in 58.82).

All the other circumstances (such as atmospheric resistance, method of lubricating axles, speed, curves, &c.) influencing the traction resistances were the same for all these trains; and it was found that if the traction resistance on a level was represented by a , that upon a gradient of an inclination i was exactly represented by $a + i$, thus agreeing with the well-known geometrical formula.

Influence of the Length of Trains.

We have already stated, that in passenger-trains the resistance per ton became less as the length of the train was increased. The reason of this is that the atmosphere exercises a greater resistance to the first carriage than to any of the others; and the average resistance per carriage is thus reduced as the number of the latter is increased.

In goods trains the length is generally much greater, whilst the speed is less. The resistance of the air is thus of less importance; whilst, on the other hand, the length has the effect of rendering the line of traction oblique on curves, and thus increasing the frictional resistance; in consequence, it was found that in the case of goods trains the resistance per ton was in general augmented by an increase in the length of the train.

Thus it was proved that, on a section of the line where there were numerous curves of 1000 metres (3280 ft.) radius, a train of 42 wagons required an average traction force equal to 1 kilogramme per tonne (2.24 lb. per ton) greater than was necessary in the case of a train of 28 wagons taken over the same section.

Influence of Curves.

In the case of passenger trains, the influence of curves was not felt if their radius was 1500 metres (4920 ft.) or more, and if the speed did not exceed 50 kilometres (31 miles) per hour; whilst on a curve of 1500 metres (4920 ft.) radius the resistance of a train of twelve carriages was increased 5 per cent. at a speed of 58 kilometres (34.77 miles) per hour.

In the case of a goods train of 40 wagons running at a speed of 26 kilometres (16.12 miles) per hour, the resistance was increased 1 kilogramme per tonne (2.24 lb. per ton English) on a curve of 1000 metres (3280 ft.) radius, and 1½ kilogrammes per ton (3.36 lb. per ton English) on a curve of 800 metres (2624 ft.) radius.

On the new lines, where there are curves of 400 metres (1312 ft.) radius, the influence of the curves is generally less sensible, because the length of the trains has to be reduced on account of the steep inclines which occur simultaneously with the sharp curves.

The authors refer to their complete memoir for observations on the influences of the state of the line and of the couplings.

Influence of the Speed, Resistance of the Air.

When the speed is increased, the action of the air displaced by the train is augmented; besides which the train tends to oscillate, which increases the rolling friction. Hereafter, in speaking of the establishment of formula, we shall examine the law which states that the coefficients increase as the square of the speed.

In starting, the mean resistance has been found to be 13 kilogrammes per tonne (29.12 lb. per ton) for goods trains, and 20 kilogrammes per tonne (49.28 lb. per ton) for passenger trains. The difference proves that the couplings were drawn up more tightly in the case of the passenger trains than in that of the goods trains.*

Influence of Atmospheric Currents.

The artificial wind created during the running of a train, and which has a velocity equal and opposite to that of the train itself, enables an examination to be made of the action of ordinary atmospheric currents.

For this purpose the wagon fitted with the dynamometers carried a vane, by the aid of which the direction of the wind at any moment could be read upon a horizontal divided circle. By the side of this was placed a compass.

The direction of the wind was noted in the station when the train was standing; and then when the train attained a uniform speed there was recorded the relative direction of the wind (that is, of that compounded of the natural wind and that created by the running of the train). The setting off of a diagram enabled the running speed to be determined, and there could then be constructed a parallelogram of speeds by which the absolute speed of the natural wind could be ascertained.

Thus, during the running of the train, the vane served the purpose of an anemometer.

It was by these means that it was calculated that an atmospheric current having a speed of 8.4 metres (27.55 ft.) per second produced a difference of 30 per cent. upon the resistance of a passenger-train according to whether it blew in the same or in a contrary direction to that in which the train was running.

We have in our experimental trains many examples which prove that, without speaking of exceptional atmospheric disturbances, the resistance of trains is sometimes doubled, merely by the action of the wind. The same train was found to present very variable coefficients on account of the winding of the line which caused the wind to cut the direction of motion at very different angles.

We shall now proceed to the next question of the programme:

"To find by experiment a practical formula for calculating the load which can be drawn by an engine, of which the arrangement, dimensions, weight for adhesion, and other important particulars are known."

We shall first endeavour to express mathematically the resistance per ton of the train.

Let us compare the results of our experiments with those of Harding's formula, of which the form is simple and rational.

$$(4.) \quad r = 2.72 + 0.094 \times V + \frac{0.00484 \times S \times V^2}{P}$$

In this formula,

r = the resistance of the train in kilogrammes per tonne.

V = the speed in kilometres per hour.

S = the area of the front of the train in square metres = 5 square metres (53.8 square feet).

P = the weight of the train in tonnes.

This formula has always given results agreeing very closely with those obtained by experiment.

We have, after much research, adopted the following formula, which agree well with our experimental results. They are applicable to trains running on straight lines, or on those having curves of large radius, on a level, and during good weather.

1st. Goods trains—speeds 12 to 32 kilometres (7.45 to 19.87 miles) per hour.

$$r = 1.65 + 0.05 \times V$$

for trains having the axle-boxes lubricated with oil, and

$$r = 2.30 + 0.05 \times V,$$

for trains of which the axles are lubricated with grease.

At low speeds the term V^2 , in equation (4), is of such slight importance that it may be suppressed.

2nd. Mixed and passenger trains, speed 32 to 50 kilometres (19.87 to 31 miles) per hour.

$$r = 1.80 + 0.08 \times V + \frac{0.009 \times S \times V^2}{P}$$

3rd. Passenger trains, speed 50 to 65 kilometres (31 to 40.36 miles) per hour.

$$r = 1.80 + 0.08 \times V + \frac{0.006 \times S \times V^2}{P}$$

4th. Express trains, 8 to 10 carriages, speed 70 to 80 kilometres (43.47 to 49.68 miles) per hour.

$$r = 1.80 + 0.14 \times V + \frac{0.004 \times S \times V^2}{P}$$

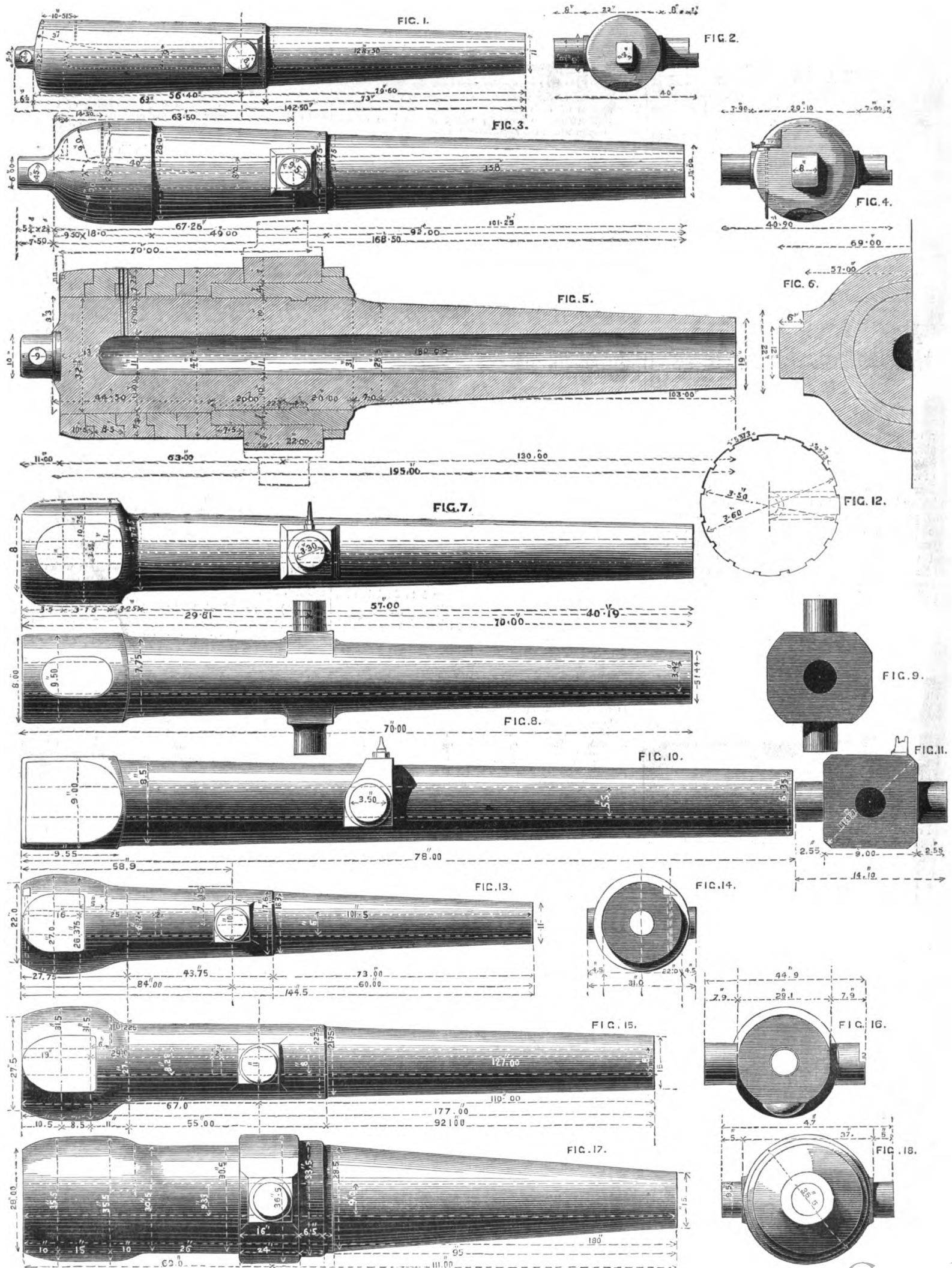
For calculating the additional resistances due to gradients, curves, &c., we refer to the paragraph concerning the second question of the programme.

(To be continued.)

THE FLORIDA AND CUBA CABLE.—General William F. Smith, the president of the Florida and Cuba Cable Company, states that the delays and failures that have heretofore occurred in the working of the line have been owing to causes beyond the control of the company; that the cable is now working through from Lake City, Florida, to Havannah, and that they hope and expect hereafter to forward promptly between these points all messages intrusted to them.

* We may mention that in France the goods wagons are generally provided with screw couplings.—Ed. E.

STEEL ORDNANCE.
 CONSTRUCTED BY MR. FRED. KRUPP, ENGINEER, ESSEN.
 (For Description, see the opposite Page.)



STEEL ORDNANCE.

CONSTRUCTED BY MR. FRED. KRUPP, ENGINEER, ESSEN.

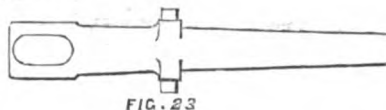
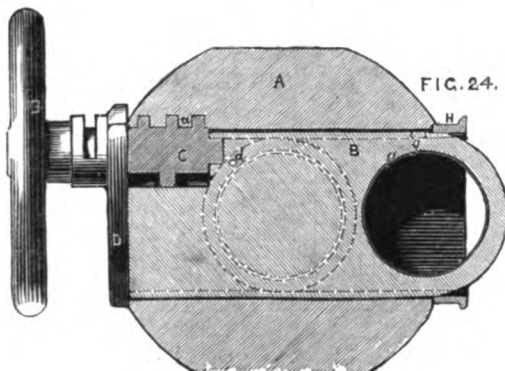
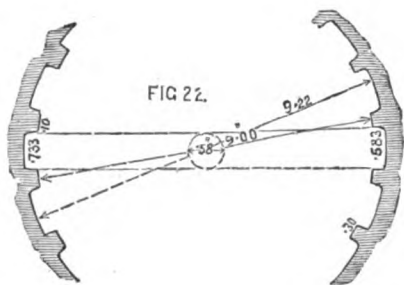
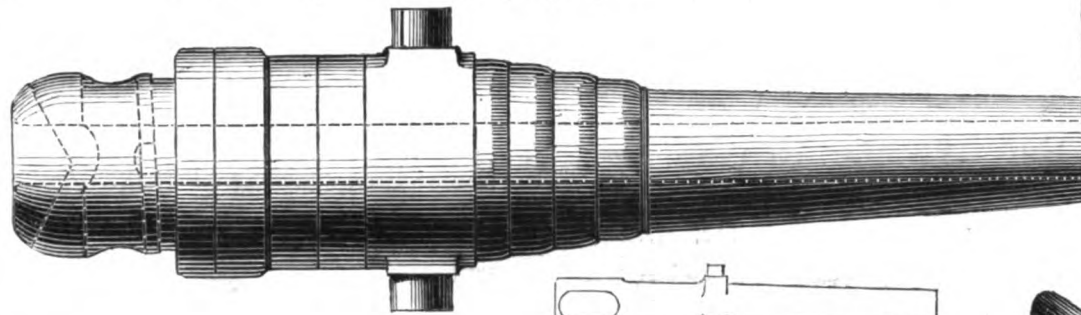
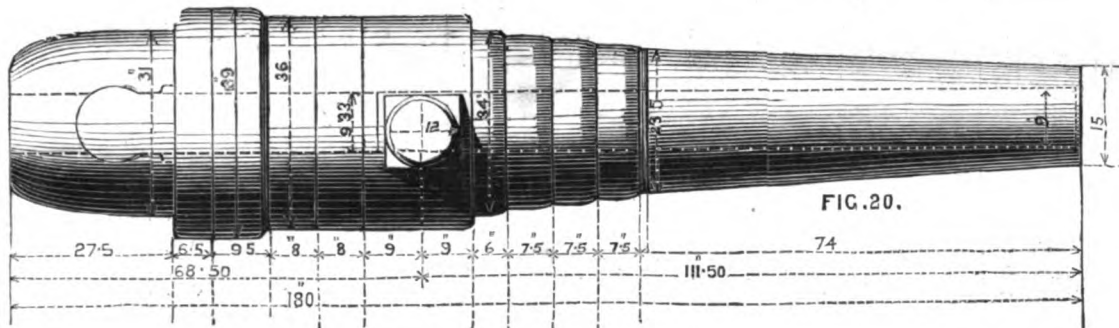
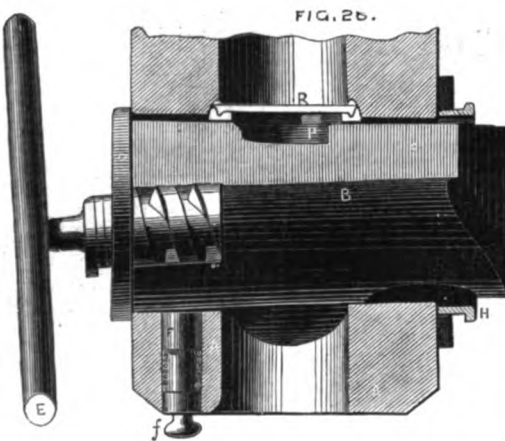
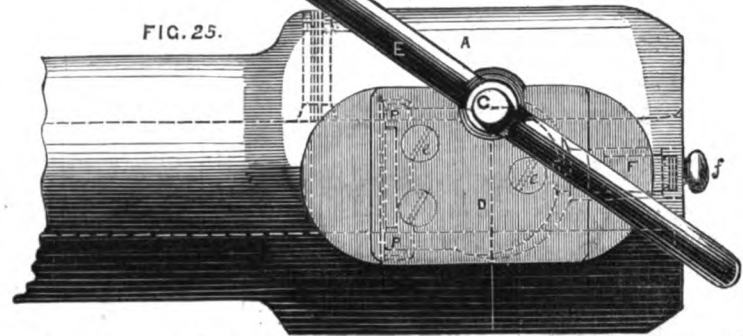


FIG. 25.



The cast-steel guns and projectiles made by M. Krupp, at Essen, are a subject of very great and general interest at this present moment. M. Krupp has furnished some of the largest and most powerful armies with his steel guns, it may be said almost to the exclusion of all other private manufacturers, and we know upon sufficiently reliable authority that M. Krupp is now in treaty with several Governments, which were not as yet amongst his regular customers, for the supply of considerable numbers of his steel guns. It will therefore be interesting to our readers to be made more closely acquainted with the correct details of construction and the general dimensions and proportions adopted by M. Krupp for his guns and projectiles. We annex engravings showing some of these designs, which are reduced from correct working drawings made at the Essen works.

Figs. 1 to 6 represent the muzzle-loading steel guns made at Essen for the Russian Government. The dimensions are in English measures, as marked on the engravings. Figs. 1 and 2 show the 6 in. gun; Figs. 3 and 4, the 8 in. gun; each made of a solid block of steel, and bored out of solid. Figs. 5 and 6 show the 11 in. gun in section. This is built up from a solid core, upon which a single row of steel rings is shrunk on the breech and a double ring at the trunnions. Figs. 7 to 11 are breech-loading steel guns of different sizes. Figs. 7, 8, and 9 show the 4-pounder breech-loading gun used in Prussia. The mode of construction of the breech is illustrated in detail in Figs. 24 to 26, and will be referred to hereafter. The gun is made of a solid block of cast steel; it weighs, when completed, the breech-piece included, 615 lb.; the bore is 3.42 in.

(English) in diameter, and rifled with twelve grooves of 0.05 in. depth; the pitch of rifling is 148.28 and 141.07 in.; the length of sight-line 28.5 in. The loaded shell weighs 11.5 lb., and the normal load of powder is 1.6 lb. Fig. 5 is a 6-pounder gun of similar construction. It weighs, inclusive of the breech-piece, 850 lb., and its diameter of bore is 3.50 in. It has sixteen grooves of 0.4373 in. width at the mouth, and 0.5873 in. width at the chamber. The depth of the grooves is 0.05 in., and the pitch 180 and 173 in. respectively. The loaded shell weighs 13.7 lb., and the normal charge is 1.2 lb. of powder. Figs. 13 to 16 are intended for different arrangements of breech. They are a 6 in. and an 8 in. gun (English measure). The 6 in. gun weighs 85 cwt. complete, with breech-piece; it has 24 grooves of 360 and 370 in. pitch. The spaces between the grooves are 0.115 in. wide at the chamber and 0.26 in. at the mouth of the gun, the grooves being 0.67 in. and 0.525 in. respectively; the weight of the solid shot, complete, is 80 lb. The 8 in. gun weighs 178 cwt., and has 30 grooves of 480 and 494.6 in. pitch. The width of grooves is 0.748 in. at the chamber and 0.552 in. at the mouth; the weight of solid shot 195 lb. Figs. 17 to 26 are two samples of 9 in. guns. The gun shown by Figs. 19 to 22 weighs 256 cwt. complete. It has 30 grooves of 540 in. and 552.9 in. pitch, and 0.733 and 0.589 in. width. The grooves are 0.11 in. deep. The loaded steel shell weighs 250 lb., and the charge of powder 40 to 50 lb. Fig. 9 is another 9 in. gun. It weighs 290 cwt. The 32 grooves have a pitch of 582.37 and 597.76, and the width is 0.733 in. at the chamber and 0.583 in. at the mouth. The loaded steel shell is the same as before, and the charge of powder 30 to 40 lb.

The breech-loading arrangement for the smaller guns, as patented and made by M. Krupp, is shown in its details in Figs. 23 to 26. A is the breech of the gun, bored right through for the insertion of the charge from behind; B is the wedge or breech-piece. It is of a cylindro-prismatic form, with a flat front, as shown at B, so that it presents a straight surface to the chamber of the gun, and is itself held behind in a cylindrical recess. There is a certain amount of taper given to the so-called cylindrical part, so that, strictly speaking, the latter is a truncated cone; but, for convenience sake, we will maintain the word cylindrical, as used by the inventor. The breech-piece is removed sideways by opening the screw, C, with the handle, E, and then pulling the breech-piece straight out into such a position as to bring the loading-ring, G, across the chamber. The breech-piece, B, is held in that position by the stop-pin, F. The gun is then ready for loading, and after insertion of the charge the breech-piece, B, is pushed back into its first position. It is then only required to bring it home deep enough into its conical seat, and this is effected by the short screw, C, which is operated upon by the handle, E. The operation of opening and closing the breech is very rapid, and it has given very satisfactory results.

We shall, next week, give a further account of some of Mr. Krupp's guns, and of the projectiles used with them.

THE HUMBER BRIDGE.—The proposal to bridge the Humber is again revived. Two years ago Mr. C. S. Todd designed a bridge of over a mile in length, between Hessele, on the Yorkshire coast, and Barton, on the Lincolnshire coast—the river passing over the chalk between those points. This bridge in connexion with the Eastern Counties Railways was to have given an independent route from Hull to London, and by the Sheffield system to the manufacturing districts. In connexion railways were projected from Hull by Pocklington, Melton, Helmsley, and Stockton to the north, bringing the Humber into connexion with the Tees and the Tyne. So far as regards the Humber bridge, the scheme is being revived, but another proposition has also been made to try as an experiment the great scheme of M. Boulet, the French engineer, who proposes a bridge from England to France. If what we have heard about M. Boulet's plans are correct—viz., that he proposes to carry his bridge on piers formed of piles, the sustaining power increased by gigantic buoys attached to them—we should think that the Hull Chamber of Commerce had better have nothing to do with his scheme.

RAILWAYS IN TURKEY.—The Sultan is pressing his ministers to do something for the development of railways, and the Government has given the concession of the Roumelian railways to M. Vander Elss, of Brussels, who is to execute 450 kilometres of it before issuing any shares as bonds. This would entail an expenditure of 3,000,000*l.* The concessionaire assures every one that he has first-class houses behind him, and so he must have if he really means to carry out the concession. The Government gives a guarantee of so much per cent. according to the section executed, and varying from 21,000*l.* to 25,000*l.* per kilometre. Until the definite plans and surveys are made it is impossible to say how much this represents, but the calculation is that it would average 7 per cent. on the cost.

THE DEPUTY DIRECTOR OF ADMIRALTY WORKS.—Mr. Scamp, deputy director of Admiralty Works, is now on a final visit of inspection of the Admiralty Works at Portsmouth, as being carried into effect according to his great scheme for the extension of Portsmouth dockyard, and for the construction of the head-quarters, barracks, &c., for the Royal Marine Artillery at Eastney. It is rumoured that Mr. Scamp has applied to the Admiralty to be relieved of the duties of the office which he has now filled for the last thirty years. The works designed by him and executed under his superintendence at all our home naval establishments, and at Malta, Gibraltar, and Bermuda, are of a very extensive, varied, and interesting character, and remain a worthy subject for future description and comment.

THE MIDDLE LEVEL.—A new series of Middle Level actions are likely to come on for trial. The arbitration in the matter of the claims for compensation for damage done by the late flood in the fens has not proceeded satisfactorily to some of the claimants, the Middle Level Commissioners refusing to meet any claims not made within two years. The flood, which forms the groundwork of the litigation occurred in May, 1862.

LOCOMOTIVE ACCOUNTS.

COMPARATIVE STATEMENT OF RECEIPTS, MILEAGE, AND LOCOMOTIVE EXPENSES ON VARIOUS ENGLISH LINES.

Half Year ending July, 1867.

Traffic Receipts.	Midland.			Great Northern.			Great Eastern.			Great Western.			North-Eastern.			Bristol and Exeter.			London and North-Western.		
	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.
	Receipts.	Average per train mile.		Receipts.	Average per train mile.		Receipts.	Average per train mile.		Receipts.	Average per train mile.		Receipts.	Average per train mile.		Receipts.	Average per train mile.		Receipts.	Average per train mile.	
Train Miles	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Passengers	458,358	1 5	...	887,516	13 8	4 3.63	415,511	14 4	...	955,422	6 0 5	6.13	447,892	11 0 3	10.78	110,659	14 11 5	6.44	1,276,411	19 4 4	10.46
Goods	907,494	13 4	...	580,193	0 4	4 5.66	429,991	6 6	...	969,179	0 1 5	7.65	1,305,838	6 5 6	0.43	64,612	10 5 7	8.35	1,758,290	14 1 1	2.32
Total	1,365,852	14 9	...	967,709	14 0	4 4.83	845,503	0 10	...	1,924,601	6 1 5	6.89	1,753,730	17 5 5	3.53	175,272	5 4 6	2.10	3,034,702	13 5 5	6.71
Locomotive Expenses.	Midland.			Great Northern.			Great Eastern.			Great Western.			North-Eastern.			Bristol and Exeter.			London and North-Western.		
	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.
	Cost.	Average cost per mile.		Cost.	Average cost per mile.		Cost.	Average cost per mile.		Cost.	Average cost per mile.		Cost.	Average cost per mile.		Cost.	Average cost per mile.		Cost.	Average cost per mile.	
Coke, Coal, and Firewood for Engines	45,579	2 3 1.76	...	46,981	18 3 2.44	2.37	37,500	15 2 2.61	2.55	53,585	4 5 1.80	1.59	104,056	6 5 3.08	...	6,048	17 5	...	88,726	11 11 1.95	...
Wages for Enginemen and Firemen	44,457	7 7 1.72	...	27,319	9 9 1.42	1.38	23,211	14 10 1.61	1.58	52,619	7 8 1.77	1.56	56,089	7 9 1.98	...	...	...	...	79,157	2 7 1.74	...
Wages for Cleaners, Cokemen, &c.	13,851	9 4 .53	...	19,089	8 6 .63	.60	7,112	5 4 .50	.48	13,562	1 11 .45	.40	24,959	11 2 .88	...	...	...	...	29,684	12 6 .65	...
Oil, Tallow, and sundry running stores	10,770	6 10 .41	...	5,185	4 8 .27	.26	9,759	14 10 .68	.66	8,680	18 7 .29	.25	11,001	13 10 .39	...	...	...	...	15,781	15 4 .34	...
Wages and materials for repairs and renewals of Engines and Tenders	79,406	17 8 3.07	...	78,517	19 4 3.82	3.71	35,236	7 9 2.45	2.40	97,106	11 11 3.27	2.88	108,386	13 10 3.83	...	8,254	6 0 3.49	...	144,009	2 2 3.16	...
Water, including pumping engine	4,266	17 8 .16	...	4,952	1 6 .25	.25	3,224	5 1 .23	.21	6,214	8 9 .20	.18	...	...	...	1,334	13 9	...	...	...	...
Salaries of Superintendents, Clerks, &c.	4,588	16 2 .17	...	15,648	9 4 .81	.79	3,588	12 9 .24	.24	5,449	9 10 .18	.16	4,504	12 8 .15	...	749	10 11	...	11,967	10 4 .26	...
Gas, Rates, Buildings, &c.	2,957	10 5 .11	...	185,694	11 4 9.67	9.38	119,633	15 9 8.33	8.15	4,007	2 2 .13	.12	...	...	...	...	...	...	82,987	18 5 .72	...
Total gross receipts	205,878	7 11 7.97	...	9,776	17 6	...	6,598	8 5	...	241,225	5 3 8.13	7.16	308,998	5 8 10.92	...	21,034	17 8	...	402,314	13 3 8.84	...
Less for power supplied	10,113	10 2	...	175,917	13 10 9.60	...	113,085	7 4 8.24	...	11,152	12 8	...	2,409	10 0	...	† 1,278	8 9	...	...	...	...
Percentage on Traffic Receipts	14.33		...	18.17		...	13.32		...	11.95		...	17.48		...	12.73		...	13.25		...
Mileage.	Midland.			Great Northern.			Great Eastern.			Great Western.			North-Eastern.			Bristol and Exeter.			London and North-Western.		
	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.
	Mileage per engine per annum.			Mileage per engine per annum.			Mileage per engine per annum.			Mileage per engine per annum.			Mileage per engine per annum.			Mileage per engine per annum.			Mileage per engine per annum.		
Gross Train Miles	2,630,965	3,562,257	6,193,222	1,702,004	2,905,852	4,607,856	1,491,208	3,444,764	4,935,972	3,583,025	3,585,290	7,118,315	2,297,515	4,489,092	6,786,607	399,707	167,909	567,616	5,239,733	5,677,300	10,917,033
Gross Engine Miles	...	...	...	1,804,227	2,946,524	4,750,751	...	3,519,961	...	3,774,414	4,304,226	8,078,640	...	...	...	...	...	...	...	...	...
Average Mileage per Engine per Annum.	Midland.			Great Northern.			Great Eastern.			Great Western.			North-Eastern.			Bristol and Exeter.			London and North-Western.		
	No. of Engines.			No. of Engines.			No. of Engines.			No. of Engines.			No. of Engines.			No. of Engines.			No. of Engines.		
	Mileage per engine per annum.			Mileage per engine per annum.			Mileage per engine per annum.			Mileage per engine per annum.			Mileage per engine per annum.			Mileage per engine per annum.			Mileage per engine per annum.		
Passenger Engines	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Goods Engines	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total	...	21,101	...	...	20,343	20,974	...	18,418	18,892	...	17,050	19,350	...	16,177	21,172	...	15,989	...	...	15,742	...

* Including Cokemen.

† Add working trains over other companies' lines.

‡ Including ballasting.

Comparative Statements of the Cost of the Locomotive, Carriage, and Wagon Departments of the leading Railway Companies for the Half-Years ended 31st December, 1866, and 30th June, 1867.

Name of Railway.	Half-Year ended	Total Train Mileage.	Total Receipts for Traffic only.	Total Locomotive cost.	Cost per Train Mile.	Percentage on Receipts.	Total Carriage and Wagon Cost.	Cost per Train Mile.	Percentage on Receipts.	Total Cost per Train Mile.	Percentage on Receipts.	Average total Cost per Train Mile for the Year.	Average percentage on Receipts for the Year.	REMARKS.
			£	£	d.		£	d.		d.		d.		
Great Eastern	{ 31st December, 1866 30th June, 1867	3,612,286 3,444,764	968,727 845,503	142,399 114,548	9.44 7.98	14.70 13.55	34,414 30,710	2.28 2.14	3.55 3.63	11.72 10.12	18.25 17.18	10.92	17.71	{ £13,736 for engines, &c. } Expended on capital { 2,400 for carriages, &c. } account. { £24,048 for locomotive renewals, and £5,973 for } { carriages, &c., renewals, included in these sums } { for half-year to 31st December, 1866. }
London and North- Western	{ 31st December, 1866 30th June, 1867	11,118,313 10,917,033	3,329,217 3,034,703	421,990 413,447	9.09 9.09	12.82 13.62	119,199 123,769	2.57 2.72	3.58 4.07	11.66 11.81	16.40 17.69	11.73	17.04	{ £54,186 for engines, &c. } Do. { 126,255 for carriages, &c. } Do. { £58,390 for engines, &c. } Do. { 80,516 for carriages, &c. } Do.
Great Northern	{ 31st December, 1866 30th June, 1867	4,532,891 4,395,959	1,064,853 967,710	178,750 178,984	9.46 9.77	16.78 18.49	48,073 47,961	2.54 2.62	4.51 4.94	12.0 12.39	21.29 23.43	12.19	22.36	{ £2,830 for engines, &c. } Do. { 46,082 for carriages, &c. } Do. { 2,268 for machinery, &c. } Do. { £43,238 for engines, &c. } Do. { 2,535 for carriages, &c. } Do. { 1,558 for machinery, &c. } Do.
Midland	{ 31st December, 1866 30th June, 1867	6,320,165 6,193,222	1,438,583 1,365,853	199,266 198,180	7.57 7.68	13.85 14.51	49,017 42,807	1.86 1.65	3.40 3.13	9.43 9.33	17.25 17.64	9.38	17.44	{ £50,130 for engines, &c. } Do. { 92,683 for carriages, &c. } Do. { 6,544 for machinery, &c. } Do. { £66,580 for engines, &c. } Do. { 128,517 for carriages, &c. } Do. { 5,779 for machinery, &c. } Do.
North-Eastern	{ 31st December, 1866 30th June, 1867	...	1,912,938 1,753,731	296,031 306,589	...	15.47 17.48	129,920 132,575	...	6.79 7.56	...	22.26 25.04	...	23.65	{ £185,396 for rolling stock. } Do. Train mileage not shown in report. { £109,187 for rolling stock } Expended on capital account.
Caledonian	{ 31st December, 1866 30th June, 1867	4,272,217 4,275,286	847,365 852,782	109,566 107,307	6.15 6.02	12.93 12.58	23,398 19,056	1.31 1.07	2.76 2.23	7.46 7.09	15.39 14.81	7.27	15.10	{ £111,289 for engines, &c. } Do. { 53,870 for carriages, &c. } Do. { £53,962 for engines, &c. } Do. { 21,052 for carriages, &c. } Do. { £11,242 for engines, &c. } Do. { 39,443 for carriages, &c. } Do. Train mileage not given in half-yearly report.
North British	{ 31st December, 1866 30th June, 1867	...	664,427 648,698	121,634 103,302	...	18.31 15.92	27,714 23,960	...	4.67 4.46	...	22.98 20.38	...	21.68	{ £18,054 for engines, &c. } Expended on capital { 3,816 for carriages, &c. } account.
Manchester, Sheffield, and Lincolnshire...	{ 31st December, 1866 30th June, 1867	2,193,822 2,127,934	497,892 470,372	61,761 66,177	6.76 7.46	12.40 14.07	18,647 20,577	2.04 2.32	3.75 4.37	8.80 9.78	16.15 18.44	9.29	17.29	{ £5,000 for engines, &c. } Do. { 3,988 for carriages, &c. } Do. { £50,850 for engines, &c. } Do. { 2,450 for carriages, &c. } Do.
Great Western	{ 31st December, 1866 30th June, 1867	7,228,833 6,905,389	1,940,293 1,924,601	240,461 232,681	7.98 8.09	12.39 12.08	88,996 90,798	2.95 3.15	4.58 4.72	10.93 11.24	16.97 16.80	11.08	16.88	{ £106,394 for rolling stock } Do. { 1,828 for machinery, &c. } Do. { £90,543 for rolling stock } Do. { 2,284 for machinery } Do. { £17,800 for engines, &c. } Do. { 35,608 for carriages, &c. } Do. Train mileage not given in half-yearly report.
Lancashire and York- shire	{ 31st December, 1866 30th June, 1867	...	1,189,858 1,167,743	109,482 129,271	...	9.20 11.07	33,752 36,127	...	2.83 3.08	...	12.03 14.15	...	13.09	{ £27,873 for engines, &c. } Expended on capital { 30,420 for carriages, &c. } account.

THE PUNJAB RAILWAY.

For some time past rumour has been busy in imputing jobbery of the worst kind to the management of the Punjab Railway, in Lahore, and the Indian Government at length appointed a commission to inquire into the matter, and the railway agent was suspended. The Lahore correspondent of the *Delhi Gazette* suggests that the inquiry should be extended to the management in England, without which the exposure of the Indian corruptions appears very much like straining at the gnat and swallowing the camel. This writer says that "the bribery and corruption in England are so gigantic that people would stand aghast at disclosures that could be made;" and whether this assertion can be maintained or not, there certainly seems to be a *prima facie* case for inquiry. The question of percentages is one that should be narrowly investigated, so as to show whether there is any foundation for the existing suspicions or not. The remarks of the *Delhi Gazette's* Lahore correspondent are as follows:

"I find I am mistaken as to the inquiry sittings of the Railway Commission being concluded; it may be they will close their record of evidence on Monday, but even that is not quite certain. Those affected, or supposed to be affected, by the evidence taken by the commissioners are preparing defences against the allegations brought against them, and will, should the committee refuse to append them to their proceedings and report, as may be the case, publish them separately. Several members of the railway staff have either resigned, or their services have been dispensed with in a somewhat summary manner. Mr. L. de M. Griffe, of the correspondence office, is of the former class, Captain Kingscote, of the agent's office,

Captain Barber, barrack-master, Mr. Hamilton, a nephew of Colonel Hamilton, of Delhi, and Mr. Percival, station-master at Ghazeeabad, of the latter. Others, it is said, are likely to follow. Mr. Keene, traffic manager, who was conducting the duties of his offices at Dalhousie, was summoned to explain the reason for his requiring an enlarged establishment, and there appears some good ground for the inquiry on this head, for with only 267 miles open, and very little traffic, the establishment now entertained seems altogether extravagant, so far as the superior grades are concerned. The traffic manager's salary is 1200 rupees, two assistants at 600 rupees each, and two traffic superintendents at 300 or 350 rupees each; total, say, 3000 rupees per mensem, besides office establishments of all kinds, amounting to more than 1000 rupees, or altogether, say, 4000 rupees in the traffic department alone for managing a traffic (passenger and goods) of not 80,000 rupees a month. There are other departments of the railway that are equally extravagantly managed, and which it would be well to inquire into, and for which the agent of the company is in no way responsible. The system commenced evidently in England, where the Board are responsible for the lavish terms they granted to Messrs. Brassey, Wythes, and Henfrey, terms that were justly condemned by Sir John Lawrence, and which but for him would have been fifty thousand rupees a mile higher than they now are. You had a strong article on the subject about thirteen months ago, if I recollect right, and it would not be amiss to inquire into the mode of granting these contracts, and whether anybody was the better for their being granted at all! It is quite ridiculous to allege that the contractors expend a large amount of capital on their works. No allegation can be more unfounded. They are paid for their work month by month, and out of the payments thus made meet their local expenditure, and all material brought from England is paid for at home before the ships leave the docks! How, then, can capital be said to be required for such operations? The fact is, that while there may be some small irregularities in India, the bribery and corruption in England is so gigantic, that people would stand aghast at disclosures that could be made in which some parties in this

country are supposed to be involved. You are, of course, aware that every ironmaster at home gives a commission of from five to ten per cent. for every order that is sent him. When orders are larger, the percentage is even larger. Now imagine the sums pocketed at home by some one in the shape of commission, when orders amount, as in the case of railway materials, to millions sterling! And yet nothing is said about these matters. It is all in the way of business, and no one is the wiser for some one pocketing a trifle of fifty or sixty thousand pounds. It is no longer a mystery to me why railway companies are organised, and how poor men get rich no one knows how, though surmises may be rife."

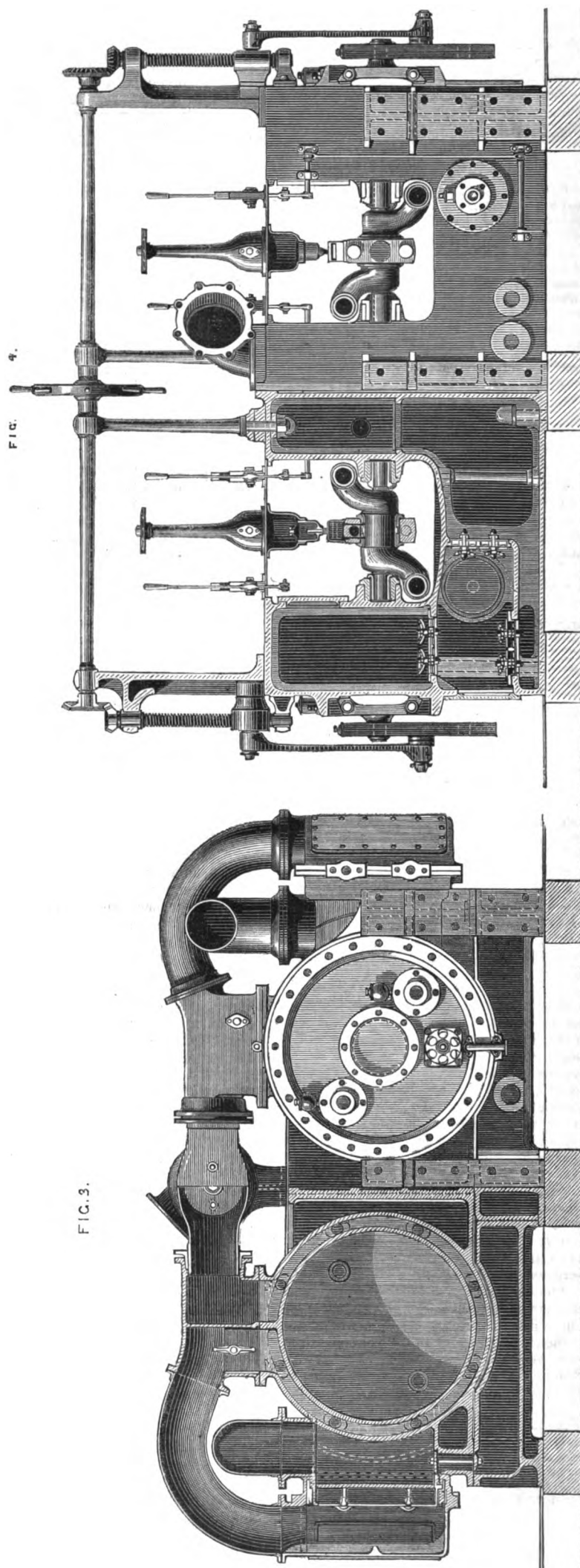
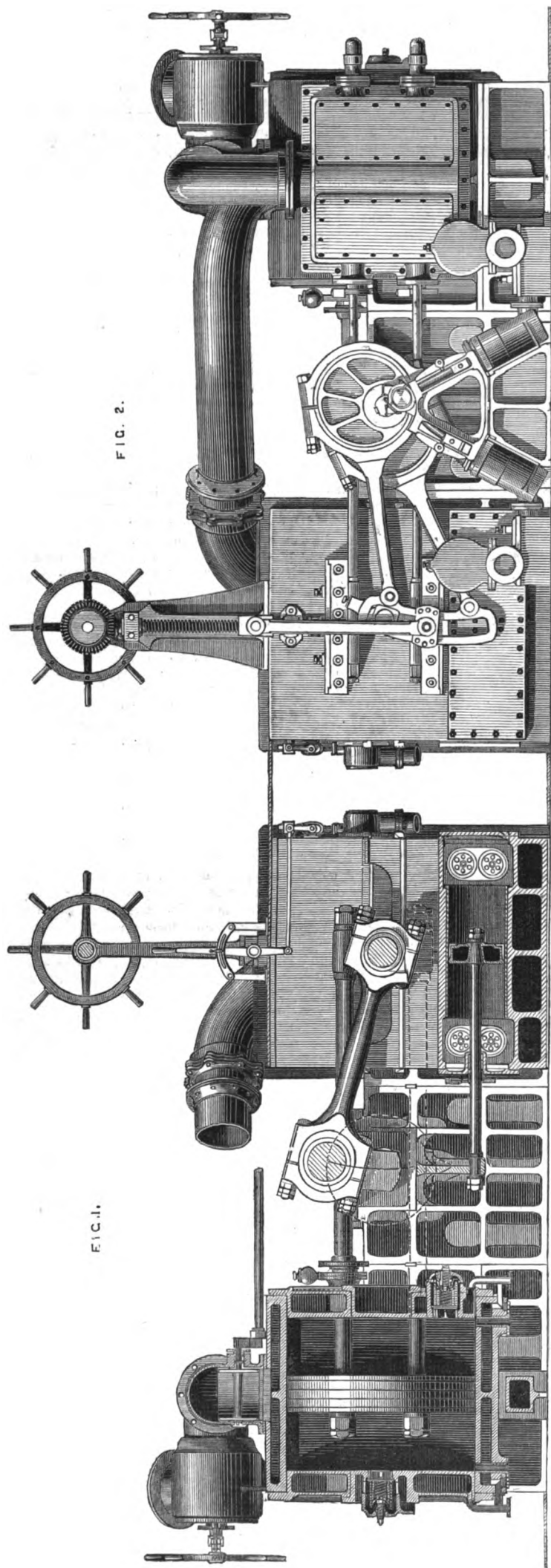
STEAM VESSELS.—A return just issued shows that on the 1st of January, 1857, there had been registered in the United Kingdom 2808 steam vessels of 869,502 tons (registered tonnage), or 1,270,240 gross tonnage. The list has to go a long time back; it includes a vessel built in 1823, the *Ann and Jane* of 27 tons, exclusive of engine-room, registered at Newcastle in 1825.

IMPORTANT DISCOVERY OF COAL IN SHROPSHIRE.—An important discovery of coal has just been made near Madeley, in Shropshire, in a district leased by the Madeley Wood Company. About three years ago a pair of pits were sunk at Kemberton at a point outside the limits originally assigned to the Coalbrookdale Coalfield, but where a more modern geological survey had ascertained that a strong probability of its extension existed. The coal has been struck at a distance of 256 yards from the surface, and the seam, known as the "top-coal," is one of the most valuable found in the district, and is invariably found in regular succession by the double coal, yard coal, best coal, flint coal, randle coal, clod coal, and little flints. It is a curious circumstance that just about this time last year the Lilleshall Company, at Priorslee, and that company, encouraged by their former success, are now engaged in prosecuting a further search in the same locality, and with every indication of similar results.

ENGINES OF THE FRENCH STEAMSHIP "CERBERE."

CONSTRUCTED BY MESSRS. SCHNEIDER AND CO., ENGINEERS, CREUSOT,

(For Description, see Page 394.)



PUBLISHER'S ANNOUNCEMENT.

Advertisements cannot be received for insertion in the current week later than 5 P.M. on Thursday. The charge for advertisements is three shillings for the first four lines or under and eightpence for each additional line.

The price of ENGINEERING to annual subscribers, receiving stamped copies at places three miles away from the General Post Office, is 1l. 1s. 8d. If credit be given, the charge is 2s. 6d. extra, subscriptions being payable in advance.

Cheques and money orders to be made payable only to Mr. Charles Gilbert.

Office for Publication and Advertisements, No. 37, Bedford-street, Strand, W.C.

ENGINEERING is registered for transmission abroad.

D. Van Nostrand, 192, Broadway, New York, is the sole American agent for ENGINEERING, and is authorised to receive all Subscriptions and Advertisements from America for this paper.

Le bureau d'ENGINEERING pour la France est 15 Quai Malaquais, Paris, chez E. Lacroix, Directeur des Annales du Génie Civil.

Subscriptions for the ANNALES DU GENIE CIVIL are received by Mr. Charles Gilbert, the Publisher of ENGINEERING, of whom also the NOUVEAU PORTEFEUILLE DE L'INGENIEUR DES CHEMINS DE FER may be obtained, price 9l.

ENGINEERING.

FRIDAY, OCTOBER 25, 1867.

GUN-COTTON.

ALTHOUGH it is now twenty-one years since, in 1846, Schönbein brought gun-cotton fairly before the public, and although more or less explosive substances, almost identical with gun-cotton in their composition, had been discovered many years previously by Braconnet and Pelouze, it is really only within a recent date that this material has been produced in such a form as to be capable of anything like practical application. The great value of gun-cotton as an explosive agent has long been known and appreciated; but its advantage in this respect was until within the last few years marred by the fact that its power could not be controlled with any degree of certainty. As formerly made, also, gun-cotton was not a stable substance—that is, it became altered and deteriorated by storage, a fault now known to be entirely due to a defective process of manufacture. Thus it was that gun-cotton fell into disrepute, and many people who in 1846 considered that Schönbein's discovery would lead to the use of gunpowder being abandoned, altered their minds, and began to look upon gun-cotton as being an interesting chemical production, but one of but little, if any, practical value.

In 1862, however, Baron von Lenk, then a captain in the Austrian artillery, brought gun-cotton again prominently before the public. Baron von Lenk established two great facts, first, that by exercising proper care in the manufacture, gun-cotton could be made more stable and uniform in its character; and, secondly, that its explosive power was capable of being regulated by mechanical means. Baron von Lenk's plan was to regulate the violence of the explosion by forming the gun-cotton into yarn, and plaiting up the yarn more or less tightly, according to the purpose for which the gun-cotton was intended. In the case of cartridges for firearms, also, various other mechanical contrivances were tried for ensuring the gradual combustion of the gun-cotton and the consequent moderation of the explosive power; but these contrivances, ingenious as many of them were, were only to a certain extent successful. The plaited gun-cotton could be made to burn with almost any required degree of slowness in the open air; but, when enclosed, the plait forming the main bulk of the charge were likely to become deranged by the explosion of the portion first fired, and the consequence was a great degree of uncertainty as to the manner in which the charges so prepared might operate.

Following Baron von Lenk, Mr. Abel, the well-known director of the chemical establishment of the War Office, has introduced most important improvements in the manufacture of gun-cotton, and its adaptation to various practical purposes. Mr. Abel has not only thoroughly tested and verified the discoveries of Baron von Lenk, but he has introduced many new methods of treating the material, which are of very great value. The main feature in Mr. Abel's plans is that he reduces the cotton-yarn, after its conversion into gun-cotton, into a pulp, this pulp being afterwards utilised in various ways according to the purpose for which the gun-cotton is intended.

At Messrs. Prentice's works, at Stowmarket, where the manufacture of gun-cotton has been carried on extensively for several years past, the system of pulping the cotton is now in regular use, and we propose, next week, to describe the whole process of production. At present we intend only to touch upon the more salient points. In the first place, they bestow great care on the thorough cleansing of the cotton-yarn before conversion, and, secondly, they are equally careful to remove all traces of acid after conversion by a most elaborate system of washing. Lately, in addition to this washing, the pulp has, at the suggestion of Mr. Abel, been finally treated with an alkaline solution, so that even the slightest traces of acid are thoroughly destroyed. In the case of mining charges, the gun-cotton pulp is subjected, whilst in the moist state, to great pressure in moulds, and it is thus formed into cylindrical "charges" of any required length or diameter. These charges are afterwards covered with a peculiar kind of paper, termed artificial vellum, and are then carefully dried at a temperature of about 140°.

For producing gun-cotton cartridges for fire-arms a different process is followed. In this case the gun-cotton pulp is mixed with a certain proportion of ordinary cotton pulp—an important point in the manufacture—and then made into a thick kind of paper, which is afterwards cut into slips, rolled up into cartridges, enclosed in a case, and covered with a thin coating of india-rubber, some exceedingly ingenious machines being employed for carrying out the various operations. When in full work, these machines turn out 16,000 cartridges per day, a fact which will give some idea of the extent of the manufacturing operations at Stowmarket. The cartridges, we should mention, are manufactured in a distinct department of the works, and the power of production above mentioned refers to this department alone, the manufacture of the mining charges occupying an independent section of the establishment.

The system of manufacture now followed by Messrs. Prentice—a system which, as we have said, we shall describe in detail next week—has not been arrived at without much expenditure both of time and money. There has probably not been a process connected with the manufacture of gun-cotton, proposed during the last few years, which has not been more or less experimented upon at Stowmarket, and it is a great feature in their system of manufacture that any process has been, and is, at once discarded on it being proved that a better one can be substituted for it. By proceeding in this way they have at length got gun-cotton under command, and they are now capable of producing a material the explosive power of which can be regulated almost as desired. We say, *almost*, because there is still at least one purpose for which gun-cotton has not yet been adapted with perfect success, and this is as an explosive to be used in heavy ordnance. The production of a form of gun-cotton suitable for use in ordnance is, however, probably only a matter of time.

For small arms, and particularly for mining purposes, the advantages of gun-cotton seem to be very thoroughly established. As compared with gunpowder, it has the advantage of not being injured by moisture, and it can thus be stored in a wet state with perfect safety, and dried as required for use. It must, however, be *thoroughly* dried, and this is a point which should be kept in mind by all who use gun-cotton. In the case of mining operations, it enables a greater amount of explosive power to be concentrated in a given space than when gunpowder is employed, and the fact of its producing no smoke when exploded is also a great point in favour of its use for underground working. It is now being very extensively used for mining purposes both at home and abroad.

FERRO-MANGANESE.

In the history of the Bessemer process the name of ferro-manganese will, under all circumstances, have an important place. The manufacture of this substance (which has now been interrupted, or perhaps finally given up, by the parties who first succeeded in making it, practically and commercially) may have proved unprofitable as far as the past and present state of the market, and of the steel manufacture, is concerned; but there can be no doubt that with the further extension of the Bessemer process, and with the application of it to the manufacture of the softest kind of steel or malleable metal, such a substance will have to be again brought into the market, and it will ultimately find its place amongst the metallurgical products of every-day use in steel-making by almost all modern processes. The manufacture of ferro-manganese was commenced, at Mr. Bessemer's suggestion,

by Mr. Henderson, of Glasgow, who invented and patented a process for the production of alloys of iron and manganese, containing a high percentage of the latter metal. A Siemens furnace was erected for carrying out this process at the Phoenix Foundry, Glasgow, about three years ago, and the manufacture of ferro-manganese was commenced with apparently good commercial results, and certainly with the greatest success, as far as the quality of the product was concerned. The metal has a price in the market depending upon its percentage of manganese, the steel-makers paying 1l. per ton of ferro-manganese for each per cent. of pure manganese contained in it. A ton of ferro-manganese, for example, guaranteed to contain 23 per cent. of manganese, was sold at 23l., and at that price it was upon a par, as far as manganese is concerned, with the average of German spiegeleisen which (containing about 7 per cent. of manganese) stood at 7l. in the quotations of iron-merchants in this country. The mode of manufacture, according to the prescriptions of the patent laws in this country, ought to have been clearly and intelligibly described by Mr. Henderson in his final specification but this document is one of the most remarkable articles of its kind, and defies any attempts to put an intelligible construction upon its mysterious wording. In fact, we have no hesitation in stating that this patent of Mr. Henderson's is void and illegal, on account of the non-fulfilment of the first and most important condition upon which a patent is granted in England, viz., the filing of a clear and intelligible specification.

The mode of manufacture, as carried on in the Phoenix Foundry, consisted in mixing carbonate of manganese—a substance obtained in soda works as one of the products of the manufacture of bleaching-powder—with an almost equal quantity of a pure calcined iron ore, also drawn from a soda works, in which it formed a kind of refuse. The original substance which yields this iron ore is a kind of iron and copper pyrites found in large quantities on the south coast of Spain. This one consists principally of iron, copper, and sulphur, and each of these elements can be obtained from it by a special process. The first operation, and the one carried out at the soda works, is the conversion of the sulphur into sulphurous and finally into sulphuric acid. The ore is for this purpose calcined, or burnt, in a current of air, which converts the sulphur into gaseous acid, and leaves the residuum of iron and copper in the shape of a porous dry mass. The operation of burning this ore is at present very largely carried out at the St. Rollox Works, Glasgow, where one of the largest and finest apparatus for the manufacture of sulphuric acid is in operation. The residue is next passed into the works of the British Metal-extracting Company (Limited)—a company formed for working some of Mr. Henderson's patents for an improved mode of extracting metallic copper from its ores. Mr. Henderson calcines his ores with a mixture of salt and sulphur. He thereby causes the separation of free chlorine gas from the salt, and causes this latter to act upon the copper in the ore, which, in combination with the chlorine, forms a soluble and even a volatile substance which is drawn out in solution from the ore by means of hot water. The copper is in this manner removed in its dissolved state, and the solid matter withdrawn from this process consists of oxide of iron purified from all its admixtures, and in a state of mechanical aggregation which makes it very suitable for reduction. This iron ore, obtained as a residuum or waste product from the copper works, was the second raw material employed by Mr. Henderson for making ferro-manganese. The two substances, viz., carbonate of manganese and oxide of iron, were mixed with charcoal-powder or coke-dust, and the whole mass charged without the use of crucibles into the Siemens furnace. The reduction of both metals, iron and manganese, took place simultaneously, and the percentage of manganese increased with the temperature, but not with the quantity of manganese matter put into the charge, all surplus of the latter going into the slag, and eating through the fire-bricks of the furnace in a remarkably short time. This destruction of bricks by the chemical action of the manganese slag was, in fact, the great trouble and difficulty in this process. It went so far that the powder carried into the regenerators by the current of gases, and afterwards heated when in contact with the bricks, melted and destroyed even these portions of the furnace, and necessitated frequent repairs. The bottom of the furnaces was lined with coke-dust and graphite, and this stood better than the exposed surfaces of the fire-bricks in the other portions. The metallic alloy of iron and manganese produced ranged in its percentage from

17 to 30 per cent. of manganese, and it was very free from other impurities. The Bessemer steel works employed it for the manufacture of the softest articles, such as boiler plates, angles, &c., but its high price prevented its use in the manufacture of rails, and, consequently, the demand remained smaller than was originally expected. The manufacture of this metal has, therefore, not been continued at the Phoenix Foundry, and, consequently, this useful and valuable material does not at present exist in the market. Steel-makers are now entirely dependent upon spiegeleisen for the necessary supply of manganese, and although they have succeeded in making the spiegel give sufficiently good results, there still remains an acknowledged want of a richer manganese alloy, and this will probably make itself felt all the more when the attention of Bessemer steel makers is more largely turned to the manufacture of armour plates.

ARTIFICIAL GRINDSTONES.

We have already noticed in this journal the success which has attended the application of Mr. Ransome's beautiful process to the manufacture of artificial grindstones—a success which is so marked that there seems little doubt that the use of natural stones for grinding purposes will eventually become the exception instead of the rule. Amongst other firms, Messrs. Bryan Donkin, and Co., the well-known engineers, of Bermondsey, have tried experiments which very decisively prove the advantages of the artificial over the natural stones. Messrs. Donkin were first supplied with a pair of Mr. Ransome's artificial grindstones in December last; and early in the present year they carefully tested these stones, and compared their efficiency with some Newcastle stones at their works. Both the natural and artificial stones were mounted in pairs on Muir's plan—a system in which the peripheries of the two stones of each pair rub slightly against each other, with a view of causing them to maintain an even surface; and the two sets of stones were tried under precisely the same circumstances, except that the Newcastle stones had a surface speed more than 20 per cent. greater than that of the others.

The trials were made as follows: A bar of steel, $\frac{3}{4}$ in. in diameter, was placed in an iron tube containing a spiral spring, and the combination was then arranged so that the end of the bar projecting from the one end of the tube barely touched one of the artificial stones, whilst the other end of the tube rested against a block of wood fixed to the grindstone-frame. A piece of wood of known thickness was then introduced between the end of the tube and the fixed block, and the spiral spring, being thus compressed, forced the piece of steel against the grindstone. The same bar of steel was afterwards applied in the same way, and under precisely the same pressure, to the Newcastle stone, and the times occupied in both cases in grinding away a certain weight of steel from the bar were accurately noted.

The results were that a quarter of an ounce of steel was ground from the bar by the artificial grindstone in *sixteen minutes*, whilst to remove the same quantity by the Newcastle stone occupied *eleven hours*; and this notwithstanding that the surface speed of the latter was, as we have stated, more than 20 per cent. greater. Taking the 20 per cent. greater speed of the Newcastle stone into account, it will be seen that the 11 hours run by it were equal to $13\frac{1}{2}$ hours at the same speed as the artificial stone, and the proportional times occupied by the two stones were thus as 16 minutes to $13\frac{1}{2}$ hours, or as 1 to 52, nearly!

Such a result as this is something more than remarkable, and it is one which would scarcely have been credited, even by those who made the experiments, if it had not been fully corroborated by subsequent experience in the working of the artificial grindstones. Since the experiments above described were tried, Messrs. Donkin have set another pair of the artificial stones to work, and these, which are now in regular use, have given even more satisfaction than those first tried. The saving in time and, consequently, in labour effected by the use of the artificial grindstones is, in fact, so great, that Messrs. Donkin have determined to use these stones exclusively in future; and we may add that the artificial stones are so much preferred by the workmen, that those men, even, who are employed in shops at some distance from that in which the stones at present in use are situated prefer taking the trouble to go to them to using the Newcastle stones in their own shops. In addition to their great efficiency, the artificial grindstones possess the advantages of being able to be manufactured of any size, and of any degree of coarseness of grain, and they can thus be specially adapted to any particular class of work, whilst the

process of their manufacture ensures their being of uniform texture throughout, and free from the flaws and hard and soft places found in natural stones. Altogether, we believe that the general adoption of the artificial grindstones is merely a matter of time.

LOCOMOTIVE ECONOMY.

(Continued from page 337.)

A most important question for locomotive engineers, one which, although it was supposed to have been settled years ago, is still open, is that of the best diameter of driving-wheel for fast traffic. Nearly all are now agreed that large wheels, say from 7 ft. to 8 ft. in diameter, are objectionable. By their use the speed of the pistons is kept down to a moderate limit, but they involve great engine weights.

With the same stroke and the same average pressure of steam upon the piston, an engine, with but $1\frac{1}{4}$ in. cylinders and 5 ft. wheels, has the same tractive force as one with 18 in. cylinders and 8 ft. wheels. For the same speed in miles per hour the smaller wheel would, of course, have to turn $1\frac{1}{2}$ times faster than the large one, and the piston speed would be as much greater. The tyres would, of course, wear out faster; but it is a fact that steel tyres now enable locomotive superintendents to work their engines with smaller wheels than formerly. Mr. Sacré is working the express trains of the Manchester, Sheffield, and Lincolnshire Railway up what locomotive engineers understand as "steepish gradients," with coupled wheels 5 ft. 6 in. in diameter, and these do not appear to distress the engine when going 40 miles and upwards per hour. The more frequent exhaust of steam into the chimney enables the boilers of the smaller engines to boil off more water from a given heating surface in an hour than can the big-wheel, big-cylinder engines, with ever so many thousand feet of tube surface. It is notorious among locomotive engineers that no big-wheeled and big-boilered engine ever did all that was expected of it, nor could it without a more frequent blast in the chimney than can be obtained with a driving wheel making but from 210 to 240 revolutions per mile.

An important matter in connexion with locomotive boiler-making is the prevention of furrowing, to which so many types of boilers are now subject. There is good evidence that furrowing is due to mechanical and not to chemical causes, and it is found that boilers of which the joints are formed by both outside and inside strips, and which are not taxed with the strain of the cylinders fastened to the smokebox, do not furrow. In this case, too, the rivets are in double shear, and are therefore twice as strong as when used in the ordinary manner. Thick-edged plates have not come into extended use for boilers, but their advantages are evident, and deserving of more attention than is paid to them. They were, we believe, first proposed and used by Mr. Fairbairn, who employed them in making the boilers of the Grappler many years ago. They are applicable, as now rolled, only to the circumferential seams of boilers, and the longitudinal seams should be welded, as is the practice on the Midland Railway. Steam-rivetting is now largely adopted for locomotive boiler work, and hand rivetting has been quite abandoned in the best shops. Where Garforth's machine is used, care should be taken not to apply too great a strain upon the plate, and careful locomotive engineers recommend for $\frac{1}{4}$ in. plates but 25 lb. steam on a 42 in. piston, progressing by 10 lb. for each additional $\frac{1}{16}$ th in. of thickness. Firebox stays are now put in by machine in the best shops, and it is time that they were thus put in in all. As for rivet-holes, we are glad to find that a few engineers now insist upon drilled holes throughout, and in the boilers of the engines now making by the Yorkshire Engine Company for the Great Indian Peninsula Railway all the rivet-holes are drilled to template. In boilers in construction at the same works the tubes have no ferrules at the smokebox end, and it is, indeed, remarkable that these needless obstructions have been so long continued in use. They do no good, but do harm by choking the escape of soot and ashes. In American engines the smokebox tubeplate is never more than $\frac{1}{4}$ in. thick, and ferrules are never set in it. The tube ends are, as tight, however, as could be wished, for, as the drivers of that country say, "they never shed a tear." To set tubes quickly and properly, and so that they cannot leak, Dudgeon's mandril, illustrated in our pages a year ago, and now in use by Mr. Adams, of the North London Railway, is the best contrivance yet introduced. It is the fault of the patentee that he has appointed no agent and granted no licenses in England, and this wholly from neglect. He deserves to lose, as he must lose, the advantage of his really valuable invention in this country.

Those engineers who keep down the tubes of their engines to a little above the centre of the boiler, so as to give a large area of water level, find the advantage of it in a command of plenty of good dry steam. This is a point which, even yet, does not always receive the attention it deserves.

An interesting subject for careful experiment would be the determination of the best size of smokebox. This is a point which has never been fully dealt with as it deserves, although one or two clever engineers have, for a long time, insisted upon the advantages of a large smokebox. It is a fact that where it has been attempted to lessen the cubic capacity of the smokebox by contrivances for taking the gases from the tubes more directly up the chimney, a much sharper blast has been required, and the American engines, which have the smallest blast nozzles and the greatest back pressure known, have also the smallest smokeboxes, these being merely a short continuation of the barrel of the boiler.

The economy of mud-hole plugs, properly placed, is remarkable, and no locomotive engineer, accustomed to send his engines into districts yielding chalky or impure water, will misunderstand our meaning. They should be fitted not only to the bottom, but to the top of the firebox, and (at the crown) in the "hit and miss" fashion which ensures the whole of the roof of the firebox being brought under periodical inspection.

(To be continued.)

THE BROOKLYN BRIDGE.

MR. JOHN A. ROEBLING, the engineer of the suspension-bridge which is to be constructed to connect New York and Brooklyn, has recently published a report giving an account of this great work. After stating his reasons for selecting what he terms the "Park route" for his bridge, he says:

"Between the two termini the whole length of the bridge will be 5862 ft., though this may vary after the Brooklyn terminus shall have been finally located.

"Of this whole length 3480 ft. will be suspended in three openings. The central span will cross the river from pier line to pier line, without impeding the navigation, in one single span of exactly 1600 ft. from centre to centre of tower. From each tower toward the land side half spans will be supported by the land cables, 940 ft. long each, measuring from the centre of the tower to the face of the anchor-wall. From the anchor-wall on the New York side, a distance remains of 1337 ft. to Chatham-street, opposite the Registrar's Office. The distance from the anchor-wall to the Brooklyn terminus measures 837 ft. The greater length of the bridge, therefore, forms a suspension-bridge proper.

"For a better understanding of the subject, those portions between the anchor-walls and the termini I shall call approaches. These approaches will be supported by iron girders and trusses, and these will rest at short intervals upon small piers of masonry or iron columns, located within these blocks of buildings which will be crossed and occupied. These pillars will form parts of walls needed for the division of the occupied ground into stores, dwellings, or offices. In every such case the bridge floor will be constructed perfectly fire and water proof, so as to serve as a roof to the blocks of houses and stores underneath. The streets will be crossed by iron girders at such elevations as to leave them unobstructed. This can be accomplished even in the crossing of North William-street, in New York, so that on this side no necessity will arise for the vacation of any one street. In the crossing of Franklin-square, both girders and trusses will be employed. From the anchorage toward the river the bridge floor is suspended to the cables, and therefore needs no support. The elevation will be so high that the roofs of the buildings underneath will be cleared. This elevation at the anchorage will be 85 ft. 8 in. above high tide, ascending toward the river at the rate of 3 ft. 5 in. in each 100 ft. The iron framing which forms the bridge floor is 80 ft. wide. This width is divided in five spaces marked by six lines of iron trusses. The two outside spaces are 15 ft. wide in the clear between the chords, and 15 ft. 5 in. between the posts, and form roadways for all kinds of common travel. Iron tramways are laid down, 13 in. wide, for the wheels to run on the same arrangement as on the Cincinnati bridge, leaving a width of $\frac{1}{4}$ ft. 8 in. in the clear for horses to walk on. The remaining 6 ft. serve as a sidewalk for pedestrians. All vehicles and passengers who go by the roadways will take the right-hand track, which arrangement will prevent crowding and confusion. The next two spaces are 13 ft. wide each, and are to be provided with steel rails for the running of two passenger trains of cars, back and forward, alternately. These trains will be attached to an endless wire rope, which is to be propelled by a stationary engine, located on the Brooklyn side, underneath the floor. These two tracks, therefore, will be treated exactly like an inclined plane, an operation perfectly simple and perfectly understood. I propose an effective running speed of 20 miles per hour, as perhaps the one most likely preferred. But this speed in the centre of the bridge may be increased to 30 and even 40 miles per hour, with entire and absolute safety. The starting and stopping will be gradual, and will be entirely under the control of the engineer. Allowing for the discharge of a train one minute, and for its filling another minute, including the time consumed in stopping and starting the train, there remain three minutes to run over one mile of the bridge. The number of cars may be increased to ten in each train, each car 50 ft. long from coupling to coupling, and $11\frac{1}{4}$ ft. wide outside, with a capacity to seat one hundred persons comfortably. Each car is to be divided crossways into eight coupes or sections. Each section will have two seats, fronting each other, and each seat will admit six to eight persons. I allow in

this estimate twelve to thirteen persons for each section, or about one hundred persons for one car. Each section has two opposite doors, one for coming in, the other for going out. These doors are to be suspended sliding doors, and connected with each other by light bars, so that the eight doors on each side of the car can be opened or closed at one operation by the conductors. Two conductors will go with each train, and attend to the opening and closing of these doors. The different cars being all attached to the same wire rope, their relative position will be fixed, and the rows of doors on each train may be opened or closed by a small windlass on the platform at each end. Each car will be supplied with such a windlass, so that the number of cars may be either increased or diminished, or the closing and opening may be made self-acting as the trains leave or enter the depot. Each car has opposite doors; those which point forward the centre of the line are for entering, the opposite ones serve for going out. On the arrival of a train the inside passengers step out through the outside doors upon an independent sidewalk of 10 ft. wide, which leads out of the depot, either to the right or left of the central walk, without interfering with the incoming passengers. For this reason the whole width of the bridge is widened out to 100 ft. for a length of 500 ft. at each end terminus. Outside of these sidewalks are the common roadways securely fenced off. It is proposed to build the cars substantial but light, entirely of iron and steel. Another system of running cars suggests itself, which may be termed the *circulating system*. In place of a reciprocating motion of the two trains, the wire rope is kept running around in one direction only, and each car, singly, as it fills with passengers, is to be attached to the rope and started. On its arrival at the opposite end this car is detached, discharged, and run over to the other tract, and in its turn conveys a load back again. Thus the cars will be kept moving singly, in a circular route, always crossing at the ends, from one track to another. At first sight this system seems to recommend itself as the best of the two; but there will be some practical difficulties to overcome, which can only be done experimentally on a large scale. I think I can make this system work successfully; but at present I prefer the other as one perfectly established, and involving no new and untried features. The wire ropes are supported on small rollers every 15 ft. They are to be driven by steam-engines located on the Brooklyn side. These engines will be double, cranks set at right angles. Duplicate sets of engines and boilers will be provided, so that one set may always be kept in order, ready for action, should anything occur to the other. There will also be a spare wire rope, ready laid down upon the tracks, so that the old may be replaced at any time of night, should it become necessary. In a case of emergency the bridge would be taken possession of by the military authorities. Running full trains, day and night, say one train every five minutes, twelve trains with 1000 men each will be passed over to Brooklyn every hour, or 288,000 men in twenty-four hours in one direction. Adding the men who can pass on foot over the central walk and over the roadways, together with the artillery and baggage trains, the total number that may be passed without crowding would reach nearly half a million.

"The central or fifth division of the bridge floor forms an elevated promenade. At each terminus, where the bridge floor is widened out to 100 ft., the central promenade is 15 ft. wide, and its floor is on a level with the floors of the railway cars. Beyond this, where the anchorage is reached, its level will be raised to the top chords of the central trusses, as represented in the cross section of the suspended structure. At each tower the promenade further ascends 6 ft. by means of flights of steps, and is divided into two walks, which pass around the central pier, high enough to allow the railway cars to pass under it.

"The cables of the East River Bridge will have a deflection of 128 ft., which is $\frac{1}{4}$ th of the span. The best quality of iron wire, if suspended over a chasm of about 6000 ft., and with a deflection of $\frac{1}{4}$ th, or 480 ft., will only be exposed to one-third of its breaking strain. Reducing the width of the chasm to 3000 ft., the tension will only be one-sixth of the breaking strain. It is plain, therefore, that the central span of the East River Bridge, which is only 1600 ft. from centre to centre of tower, is far within the safe limits of good wire. A span of 1600 ft., or more, can be made just as safe, and as strong in proportion, as a span of 100 ft. The weight of superstructure of the East River span, as far as supported by the cable and stays, and including the weight of four steel cables, is equal to 3483 tons. The maximum transitory weight, which can at any one time come on the bridge by crowds of people on the road and footways, and the railway trains fully loaded, will be 1270 tons, making an aggregate of 4753 tons. In this calculation the maximum weight on the road and footways is assumed at 30 lb. per superficial foot, which is the actual weight of a dense crowd of people moving freely and promiscuously. More weight can be placed upon the floor, but not without packing. It is further assumed that the superstructure is suspended to four cables of 11 in. diameter each, made of the best quality of steel wire, and which are assisted by 280 stays, each stay of an ultimate strength of 100 tons neat. The aggregate strength of the cable stays will be equal to six times the tension that will result from the above maximum weight.

"The question whether iron wire or steel wire should be used in the cables need not be decided now. If iron wire is employed, the cables will have to be nearly 35 in. in diameter, in place of 11 in. of steel. To guard against vertical and horizontal oscillations, and to insure that degree of stiffness in the flooring, which is absolutely necessary to meet the effects of violent gales in such an exposed situation, I have provided six lines of iron trusses, which will run the whole length of the suspended floor from anchor-wall to anchor-wall. The iron floor beams, which are spaced in pairs, 7 ft. 8 in. apart, intersect the longitudinal trusses at right angles, and are rivetted to the middle chords and to the upright posts. The height of each truss is 12 ft., the floor being laid above the centre, so that the upper part of the truss-frames answers for protection, as well as division, in place of railings. Those

parts of the longitudinal trusses, which extend below the floor-beams, afford an excellent means for lateral trussing and bracing.

"The East River Bridge will form a huge truss of 1600 ft. span, and a depth of 150 ft. The towers form one supporting element, the framing of the floor forms the second, and the extensive system of stays forms the third. The stays are arranged in four distinct planes connected by the floor. The latter, in connexion with the stays, will support itself without the assistance of the cables. The weight of the superstructure, without cables, will be 2675 tons. Now, the supporting power of the stays alone will be 15,000 tons, ample to hold up the floor. If the cables were removed the bridge would sink in the centre, but would not fall. To uphold the centre of the bridge, to provide for greater strength and security, and to maintain the integrity of the whole, the four cables are added."

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

The Glasgow Pig-iron Market.—Since my last, the local pig-iron market has varied from "further improved" to "firm," "steady," "flat," and "quiet." Last Wednesday the prices had risen still further, and were quoted at 55s. 3d. to 55s. 6d. cash, and the same prices were obtained the following day, and 55s. 8d. at a month was taken at the close of the market. Since then prices have fallen somewhat, and a large business has been done at 55s. 3d. and 55s. cash. No. 1 Gartsherrie and No. Coltness have varied very little from 61s. 6d. The Ardrossan shipments for the week ending 17th of October amounted to 2695 tons, including some small foreign orders reaching to 395 tons. The shipments from Glasgow for the week ending 19th October were 2505 tons, including 1185 tons for foreign orders.

The Caledonian Railway Affairs.—Notwithstanding the confidence with which the chairman of the Caledonian Railway Company referred to the financial state of the company at the half-yearly meeting recently held in this city, writers in the press and pamphleteers have continued to urge that there is "something rotten in the state of Denmark," and to such an extent, indeed, that a crisis, quite a panic even, has occurred this week. Twelve months ago the Caledonian stock was at 121½; two months ago, at 113½; a month ago (about the time of the meeting), at 107½; a fortnight ago, at 104½. On Saturday last the shares closed at 92½, opened on Monday at 89, and fell by rapid strides until they reached 83½, closing at 88½. They have improved since very materially (even to 95 to-day), and so confident are the directors in the really healthy state of the affairs entrusted to their management, that they have offered to allow their books to be freely opened to the inspection of a number of the shareholders, whose commercial positions are such as to give them some claim to request such an inspection. It is very probable that a public investigation, such as the North British had to submit to, will not be called for or even be necessary.

Scotch Locomotives on English Railways.—As a pendant to your article last week on the Hyde Park Locomotive Works, I may mention one or two facts concerning the extent to which Messrs. Neilson and Company's locomotives are being introduced on English railways. Within the last two or three years, this firm has contrived to make its name known in London and other railway centres as a formidable rival to the leading English firms. For some time past the Great Northern and the London, Chatham and Dover Companies have been buying their new engines almost exclusively from Messrs. Neilson and Company, and the superiority of the finish of those specimens, which are now in the service of the companies just named, amply justifies the selection made by them. Messrs. Neilson and Company have also supplied a large number of engines, both for goods and passenger traffic, to the Great Eastern, the Manchester, Sheffield and Lincolnshire, the North Staffordshire, and other companies. The goods engines on the lines of the two companies last named are of a very powerful character, and are carefully finished in all their parts. The London, Chatham, and Dover Company have now fourteen of Messrs. Neilson and Company's engines running on their line, and they are gradually replacing the former locomotives in the working of the Metropolitan Extension of that company's system. They are all appropriately named from different islands or rivers of the north—Annan, Arran, Bute, Clyde, Esk, Iona, Islay, Jura, Kelvin, Nith, Spey, Staffa, Tay, and Ulva, forming together a perfectly uniform stock of engines probably unequalled in the kingdom.

Unfortunate Mishaps in Dundee.—A fortnight ago, two Dundee shipbuilding yards and their contents were destroyed by fire, together with many of the workmen's chests of tools. The property destroyed on that occasion was valued at 50,000l. or 60,000l. The Patent Slip Dock, closely adjoining one of the yards, was placed in imminent jeopardy by the fire, but, fortunately, it escaped. "Misfortunes never come singly," it is said, and to verify this maxim another most unaccountable accident has occurred this week at the Dundee Gas Works, not involving much damage to property, it is true, but attended with severe injuries to eleven of the workmen who were concerned, with possibly fatal injuries to three of them. Messrs. Laidlaw and Son, the eminent gas engineers of this city, are engaged in the erection of a very large gasometer, some 100 ft. in diameter, and on Monday afternoon their foreman was engaged in superintending the lowering of the first portion of it—a belt of about 4 ft. in breadth—into a circular excavation 104 ft. in diameter and 25 ft. deep, when all of a sudden, and without any forewarning, the whole belt swayed, doubled up, and fell, carrying with it the scaffolding and eleven of the men stationed on it, each of whom was taking charge of one of the twelve screws by means of which the seven tons of boiler-plate sheet iron was being lowered. The result which followed is beyond description. Where the fault lay nobody can tell, for the same lowering screws as were used have frequently had their powers tested before; only a short time ago, indeed, they were employed in lifting and lowering a gasometer in Dundee which weighed 20 tons.

The Geological Survey of Scotland.—This great work, first commenced under the personal superintendence of Professor Ramsay, is now making considerable progress in the hands of Mr. Archibald Geikie, the present local director of the survey. Mr. Geikie has just been lecturing upon this subject to the Philosophical Society of Greenock, and has stated some interesting facts about it, especially interesting to the great coal and iron masters of this country and several others embraced in the Scottish coalfield. The counties of Fife and Kinross are finished; Lanarkshire and Peebleshire were begun in 1862, and the latter is completed; but until now the geological maps have not been available, owing to the backward state of the Ordnance Survey the maps of which are used as the basis for the records of the geological surveyors. Ground was broken in the southern part of Ayrshire in the autumn of 1863. Nearly the whole of that county is now finished, and the survey is moving northwards into Renfrewshire, and eastwards into Lanarkshire. As all the 6 in. Ordnance maps of the south of Scotland are now published, it is anticipated that no further impediment will arrest the progress of the Geological Survey through the great coal-fields of Scotland.

New Rotary Engine.—The oft-attempted problem of the rotary engine has been again essayed with encouraging success by Mr. Justice, of Dundee, an engine of that type having been put by him for Messrs. Low and Duff, engineers there. It works up to 12 horse power, and occupies a space of only 4 ft. by 2 ft. 6 in., and the saving of coals as compared with the beam engine formerly at work upon the premises amounts to 2 cwt. per diem. As to first cost, we are given to understand that a 5 horse power engine of this description, with steel shafts and gun metal bearings, does not exceed 40l. The engine has given the most complete satisfaction to its owners. Professor Macquorn Rankine, we understand, while in Dundee lately expressed very great satisfaction with Mr. Justice's engine, and Mr. Justice is by special request to explain his invention at the meeting of the Institution of Engineers in Scotland, at Glasgow which takes place in a week or two.

Iron-founding Trade.—The firms in Glasgow and neighbourhood who follow this branch of industry are generally complaining, and with justice, of the stagnation of their trade. We are glad, however, to state that certain branches, such as pipe-making—a trade almost entire concentrated in Glasgow, as witness the Messrs. Edington, Messrs. D. Y. Stewart and Co., &c. &c.—all the heavier kinds of castings required for building purposes, and plumbers' and sanitary castings, continue well employed. The state of the exchequer of the Operative Moulders' Union may be taken as an index of the state of matters. Nine months ago it had funds in hand amounting to 12,000l., but so great has been the drain that that sum has been reduced to 3000l. at the present moment, the society having been paying 200l. a week as alimony to its members out of work. The workmen employed in the shops which supplied the heavy marine-engine castings have been the chief sufferers. At present 700 members are drawing a weekly subsistence money from the union, and emigration schemes are being carried through by the officials of the society in order to relieve the labour market, twenty-five single and forty-two married, with their families, having been sent to America and Australia, and arrangements are being made for the departure of other fourteen.

Northern Lights Commission.—This Board—the Scotch Trinity House—have resolved on further extension of the lighting of the coast. On the west they have determined to erect a lighthouse on Dune Point, in the island of Islay, for the purpose of guiding fishing and storm-bound Atlantic vessels to the anchorage of Lochindaul. This has already received the necessary concurrence of the Board of Trade, and will be at once proceeded with. On the east coast they have resolved on a new lighthouse at Scurdy Ness, at the south side of the entrance to the harbour of Montrose, the two guiding lights on the north side of the entrance being of use only for vessels actually entering Montrose, and useless for general coast lights.

ENGINEERING WORKS IN ITALY.—The works of the Foggia line and the port of Brindisi have been lately inspected by the Italian Minister of Public Works. A considerable portion of the Foggia line, it is said, might be opened in December, but obstacles are feared. At Brindisi it has at length been determined to form a dry dock, of the length of 120 metres. The estimated expense is 2,500,000 lire; the works are to be thrown open to competition, and offers are to be made under the obligation of constructing the basin sufficiently large to receive vessels of 2000 tons.

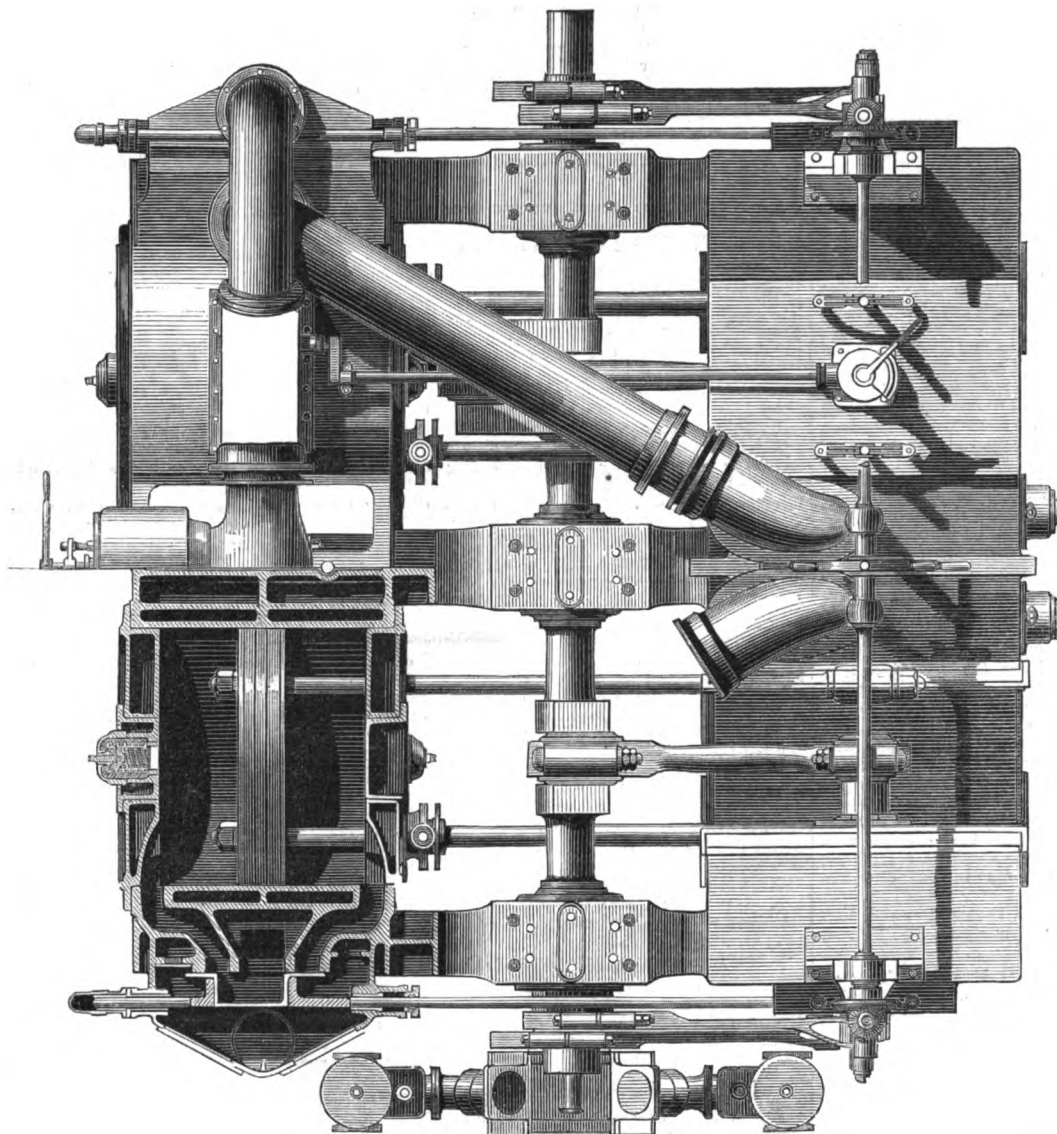
THE ST. PETERSBURG AND MOSCOW RAILWAY.—It is stated that Mr. Winans, the eminent American contractor at St. Petersburg, has proposed to buy the Moscow Railway, so long in the market, and recently offered to the Russo-French Railway Company by the Government. He is willing to pay 25,000,000 roubles within a year, besides undertaking to amortise a former loan. As some of his London partners are likely to object to the transaction, Count Stroganoff has left for England to smooth matters, if he can, on behalf of the Government.

LONDON WATER SUPPLY.—Great interest exists as to the probable nature of the report which is to be issued by her Majesty's commission, of which the Duke of Richmond is chairman, and Sir John Thwaites, Sir B. Phillips, and Mr. Harrison are members. Those interested in the existing water companies, it is said, have received an intimation that the commission will report in favour of the Thames source for the future supply of London; but if this is really so, why cannot the purport of the report be communicated to the authorities, so that it may be known that no distant source will be recommended, and therefore that the question may be considered as practically settled? The evidence of some of the first engineers of the day, it is believed, was obtained upon the subject, among whom, it may be mentioned, Messrs. Hawksley, Beardmore, Fulton, Mylne, Bateman, Bazalgette, and others. A majority of these engineers, it is believed, recommended a more distant, a purer, and a softer source than the present, but the influence of the existing water companies, it is said, is such that there is but little chance of any such measure being carried out.

ENGINES OF THE FRENCH STEAMSHIP "CERBERE."

CONSTRUCTED BY MESSRS. SCHNEIDER AND CO., ENGINEERS, CREUSOT.

FIG. 5



We give, above and on page 390, engravings of a pair of screw engines, of 530 horse power nominal, constructed by Messrs. Schneider and Co., of Creusot, for the *Cerbère*. Our illustrations show the construction of these engines so clearly that it will be unnecessary that we should enter into any minute description of them. They are of the return connecting-rod class, and, according to measurements by scale from the excellent tracings with which we have been furnished by Messrs. Schneider, the cylinders are 47½ in. (1.2 mètres) in diameter, with a stroke of 2 ft. 3½ in. (0.7 mètre). The cylinders and cylinder-covers are steam-jacketed, and, as will be seen by the section, Fig. 3, the steam used by the engines is led round the cylinders on its way from the boiler to the valve-chests. The steam ports are 2 ft. 5½ in. long by 5½ in. wide, and the valves are plain cast-iron slide-valves, not fitted with any arrangement for relieving them from the pressure on their backs. As the valves are not double ported, they have to have a somewhat long travel to give the necessary amount of opening. The air-pumps, which are double-acting, are 14½ in. in diameter, and the air-pump rods are coupled to brackets on two of the four piston-rods. The shape of the condenser and the arrangements of the air-pump valves will be seen from the half-transverse section, Fig. 4, and this figure also shows the manner in which the crossheads and their guides are constructed. The arrangement of the valve-motion, hand-gear, and other details is so clearly shown in the drawings, that it will be unnecessary that we should say more about them here.

THE THAMES CONSERVANCY.—An Act was passed in the recent session for extending to the Thames between Staines and the metropolis the provisions of the Thames Navigation Act, 1866, relating to the prevention of the pollution of the river and for otherwise extending and amending the Thames Conservancy and Navigation Acts. By the Act of 1866 the conservators were to apply to Parliament to enable them to prevent the flow or passage of sewage, or other offensive or injurious matter, and to preserve and purify the waters of the river. The provisions are now extended from Staines to the metropolis against pollution, and the conservators are empowered to preserve the flow and purity of water down to the western boundary of the metropolis. The conservators may dredge and remove shoals, &c., in the bed of the Thames, and deepen or otherwise improve the same. Other persons, under a penalty of 20*l.*, are prohibited from dredging.

RAMSBOTTOM'S TRAVERSERS.

It not infrequently happens that a departure train is delayed from a necessity arising for adding to it extra carriages, an operation which, if these carriages have to be transferred from another line of rails by ordinary turntables or traversers, involves a considerable expenditure of time. To avoid this delay, and enable a series of carriages to be rapidly transferred from one line to another, Mr. John Ramsbottom, of Crewe, has designed and recently patented the apparatus of which we give engravings on the next page.

In these illustrations, Figs. 1, 2, and 3 show respectively a longitudinal section, a plan, and a transverse section of one form of traverser constructed on Mr. Ramsbottom's plans. In Fig. 2, *aa* represent the ends of the rails of three lines of the permanent way to which the traverser is applied; *bb* are six pairs of rails secured to the links of the endless chains, *cc*, which pass around the toothed drums, *dd'*. It is evident that by reducing or increasing the length of the chains, *cc*, and the number of pairs of rails, *bb*, the machinery may be adapted to any number of lines of rails. The links to which the rails, *b*, are attached are expanded laterally to admit the connecting bolts, and the projecting ends of the joint-pins of the chains take into the toothed drums, *dd'*, the latter of which is turned round in the required direction by the shaft, *e*, and bevel-pinion, *e'*, gearing into the wheel, *d'*, on the axle of the drum, *d'*. The shaft, *e*, may be driven by hand, steam, or hydraulic power, and when hydraulic power is used the high-pressure water required may be taken from the town's mains, or it may be pumped by hand or power into a tank placed sufficiently above the level of the rails to give the desired pressure, or the water may be stored in an accumulator consisting of a cylinder fitted or provided with a loaded ram or piston, or the power may be accumulated by raising a weight, the descent of which would give the power necessary for performing the work with sufficient rapidity, as will be described hereafter in reference to Fig. 6. When the carriage to be moved has been brought on to one pair of the rails, *b*, the endless chains, *c*, are put in motion, and the carriage is thus moved laterally until the rails, *b*, on which it is supported arrive in line with the rails of the permanent way on which the carriage is required; the machine is then stopped until the carriage that has been moved has been run on to the permanent way, and during the same time another carriage may be run on to the rails, *b*, fixed to another part of the endless chains, *c*, the rails being secured in their proper places by suitable stops when necessary.

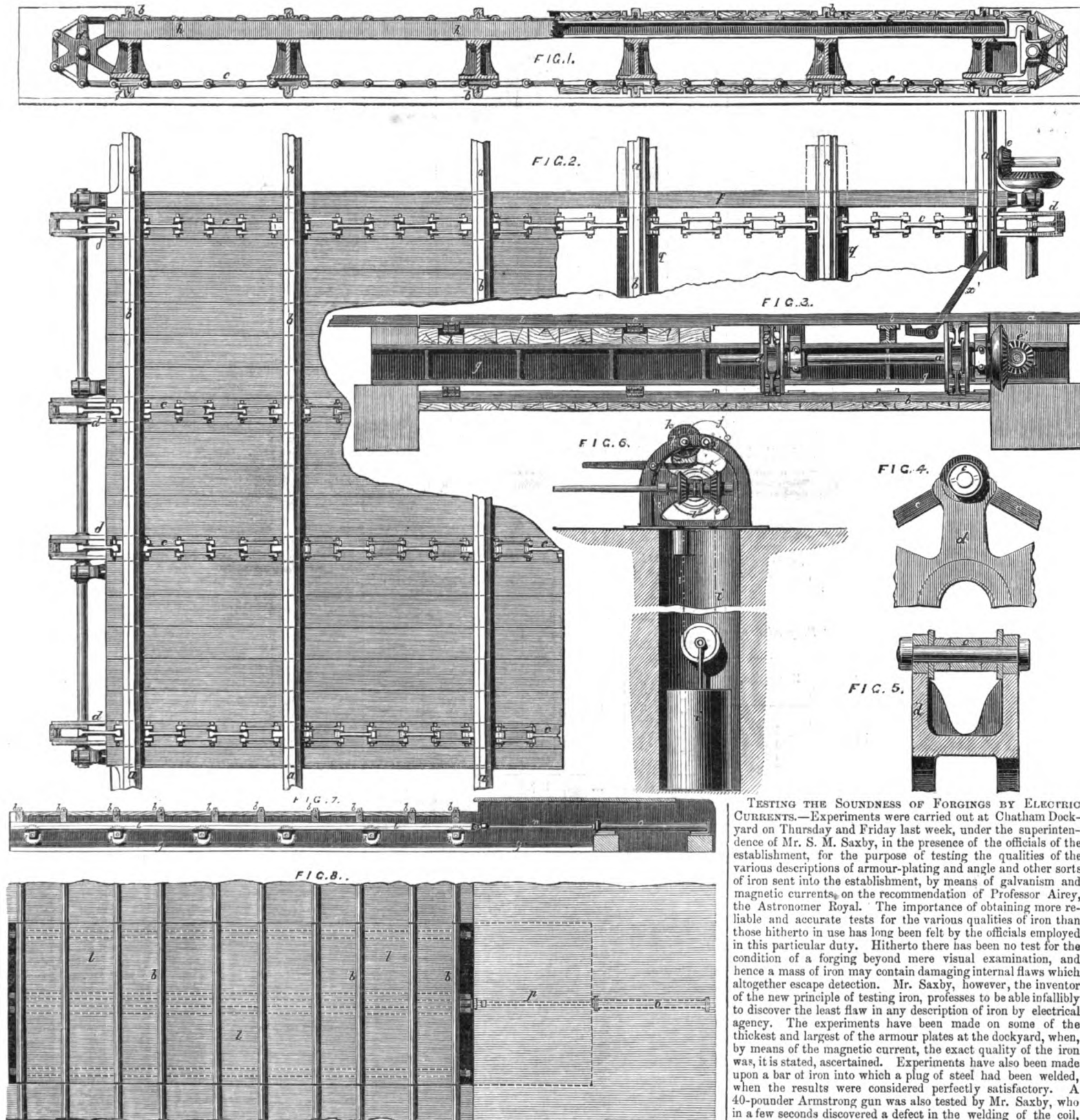
In Fig. 3 is shown one mode of securing the rails. In this figure, *x* is a cross-shaft to which is fixed the handle, *x'*, and the forked arm, *x''*, the handle is brought into a convenient position for being shifted by the attendant who applies the moving power, and when the rails are near their proper places the attendant lets go the handle to allow the forked arm to clip one of the rails. The rails, *b*, slide either on transverse beams, *f*, supported by girders, *g*, as shown on the right-hand side of Figs. 1, 2, and 3, or on baulks of teak or other hard wood, *h*, as shown to the left-hand side of the figures, and the lower parts of the endless chains are held up by the flooring to prevent them from hanging loose. To protect the transverse slides from dirt, and to afford facilities to the workmen when moving carriages or wagons upon the traversing rails, planks or boards may be placed parallel to the rails and attached to the links of the chain, as shown on the right-hand side of Figs. 1 and 2.

In Figs. 4 and 5 is shown a modification in the construction of the chains, *c*, above referred to; in these views the pins forming the joints of the links are made long enough to support the anti-friction rollers, *c'*, which take into the teeth of the drums, *d* and *d'*, and which run upon guide rails placed between the two drums, so as to reduce the friction on the chains.

Fig. 6 represents an arrangement of gearing for raising a weight, the descent of which would produce the force necessary for moving the chains, *c*, and traversing the carriage or wagon from one line of rails to another with the requisite rapidity. In this view, *i* is the weight working up and down in a pit or against the side of a building or otherwise; this weight is suspended to the chain or cord, *i'*, one end of which is secured to the chain-barrel, *i''*, and the other to any fixed point. The chain-barrel is turned round by the winch, *j*, driven by hand or other power, and the pinion, *j'*, gears into the wheel, *k*, to which is connected the pinion, *k'*, gearing into the wheel, *i''*. To the axle of the chain-barrel, *i'*, is fixed the bevel wheel, *i'*, gearing alternately in the wheels, *e''*, which are connected to the shaft, *e* (corresponding to the shaft *e* in Figs. 2 and 3), by a key and groove. When the weight, *i*, is being raised both the wheels, *e''*, are moved into a central position and out of gear with the wheel, *i'*, and as soon as the weight has been raised to the proper height it is held up by an ordinary retaining catch. When the motion is required either one or other of the wheels, *e''*, is brought into gear with *i'*, according to the direction of motion required to be given to the shaft, *e*; the retaining catch is then

TRAVERSER FOR RAILWAY CARRIAGES AND WAGONS.

DESIGNED BY MR. JOHN RAMSBOTTOM, LONDON AND NORTH-WESTERN RAILWAY, CREWE.



lifted, and the weight is allowed to descend by its own gravity, but the velocity of its descent can be regulated by applying the brake, *k*, to the wheel, *k*, if requisite. The above is only given as an illustration of a convenient mode of lifting and lowering the weight, but the machinery for effecting the same result may be varied considerably.

Another form of traverser is shown by Figs. 7 and 8, Fig. 7 being a sectional elevation, and Fig. 8 a plan, of a traversing frame suitable for four lines of rails. In these views, the traversing frame, *l*, is made with five lines of rails, *b*, and is adapted for traversing a carriage from one line of rails to the adjacent line; the frame, *l*, is supported on wheels, *h*, running upon the rails, *g*, and the piston-rod, *n*, has a piston working in the cylinder, *o*, placed under the platform. The rails, *b*, are fixed to the cross beams of the traversing frame. When this traversing apparatus is at work, a carriage or wagon can be moved from one line of rails, *a*, to the adjacent line by admitting water under pressure to the cylinder, *o*, but by increasing the length of the stroke and the relative number of rails in the traversing frame, the carriages may be moved to the second and third line of rails,

or further if required. When the traversing frame is applied to several lines of rails, it is proposed to provide handles at various points near the frame to control conveniently the moving force by which it is worked, whether it be steam, water, or other power, and retaining catches of the ordinary construction may be applied to one or more of the rails to hold the traversing frame in its proper position when moved. It will be observed that in all cases when the traversing of the carriage has been effected, the roads remain intact and safe for traffic.

POLICE STATION TELEGRAPHS.—Sir Richard Mayne, C.B., has at length determined on having all the principal police-stations in the metropolis connected with the chief office in Whitehall by means of the telegraph. The connexion of most of the stations was completed last week. In addition, an independent line of wires has been made between the chief office, and the principal station of the Fire Brigade in Watling-street, in order that the authorities may be immediately communicated with on the outbreak of any fire that might require the presence of an extra body of the police.

TESTING THE SOUNDNESS OF FORGINGS BY ELECTRIC CURRENTS.—Experiments were carried out at Chatham Dockyard on Thursday and Friday last week, under the superintendence of Mr. S. M. Saxby, in the presence of the officials of the establishment, for the purpose of testing the qualities of the various descriptions of armour-plating and angle and other sorts of iron sent into the establishment, by means of galvanism and magnetic currents, on the recommendation of Professor Airey, the Astronomer Royal. The importance of obtaining more reliable and accurate tests for the various qualities of iron than those hitherto in use has long been felt by the officials employed in this particular duty. Hitherto there has been no test for the condition of a forging beyond mere visual examination, and hence a mass of iron may contain damaging internal flaws which altogether escape detection. Mr. Saxby, however, the inventor of the new principle of testing iron, professes to be able infallibly to discover the least flaw in any description of iron by electrical agency. The experiments have been made on some of the thickest and largest of the armour plates at the dockyard, when, by means of the magnetic current, the exact quality of the iron was, it is stated, ascertained. Experiments have also been made upon a bar of iron into which a plug of steel had been welded, when the results were considered perfectly satisfactory. A 40-pounder Armstrong gun was also tested by Mr. Saxby, who in a few seconds discovered a defect in the welding of the coil, although invisible to the eye, but afterwards proved to exist. Further trials have been made on large guns and rifle barrels, with equally satisfactory results, and the experiments will be continued this week.

THE BRITISH ASSOCIATION.—A meeting of the local invitation committees of Exeter and Plymouth for securing the visit of the British Association to one of those places in 1869 was held on Thursday, to consider what steps should be taken to end the present rivalry. After much discussion it was decided to refer the question to the last three Presidents of the British Association—Professor Philips, Mr. Grove, and the Duke of Buccleuch—to say which town should retire and help the other.

TURKISH FORESTS AND MINES.—The Turkish Government is trying at last to turn to account its forests and mines, but the difficulty which frightens away every one is the want of means of communication in the interior. The concessionaires don't care to lay out the large sums which the removal of this evil would require, and the Government of course cannot do it. So, in spite of the great mineral wealth of the country, no one will take the mines. One forest district in Bosnia has been, however, sold, and is expected to yield 20,000.

ON THE STRENGTH OF STEEL CONTAINING DIFFERENT PROPORTIONS OF CARBON.

THE following paper, by Mr. Thomas E. Vickers, of Sheffield, was read during the meeting of the Institution of Mechanical Engineers at that place in 1861, but, notwithstanding the time which has since elapsed, the importance of the facts contained in it has led us to reprint it in connexion with the account of the River Don Steel Works which appears on another page of the present number.

Three most important materials of British manufacture—wrought iron, steel, and cast iron—are combinations of iron with a smaller or larger amount of carbon. Wrought iron contains from about $\frac{1}{4}$ to $\frac{1}{2}$ per cent. of carbon, cast steel about $\frac{1}{2}$ to 2 per cent., and cast iron from $2\frac{1}{2}$ to 7 per cent. The great variety of opinions that have been expressed respecting the strength of steel when containing different proportions of carbon led the writer to make a number of tests upon this point, the results of which are given in the present paper with the conclusions derived from them.

The degree of carbonisation in the several varieties of steel tested in the experiments ranged from about $\frac{1}{4}$ per cent. of carbon to $1\frac{1}{2}$ per cent.; the softest or least carbonised steel containing $\frac{1}{4}$ per cent. of carbon was called No. 2, and the hardest or most highly carbonised containing $1\frac{1}{2}$ per cent. of carbon No. 20, the intermediate numbers representing intermediate degrees of carbonisation. The tests to which the steel was subjected consisted in ascertaining its tensile strength, by means of bars of the steel broken by direct tension; and also its transverse strength, by means of axles made of the steel which were broken by the blows of a heavy ram.

Tensile Strength.—The tensile strength of the several varieties of steel was tested by a simple lever machine shown, in which the leverage is 220 in. to 11 in., or 20 to 1, so that each cwt. added in the scale at the long end of the lever produces a tension of 1 ton on the test bar at the other end of the lever. The test bars are $2\frac{1}{2}$ in. long, with $1\frac{1}{2}$ in. of their length turned down to a uniform diameter of 1 in. For facility of fixing the bars in the testing-machine and removing them when broken, the ends are made wedge-shaped, and the lower end is held in a conical socket in the holding-down block, into which it is inserted through a longitudinal slot; the bar is then turned half round, and the upper end slipped into the wedge-shaped holder at top, whereby the bar is securely held during the testing. In the following Table I give the results of the trials, showing the breaking strain reduced to tons per square inch, together with the amount of elongation produced in the bars:

TABLE I.
Tensile Strength of Steel containing Different Proportions of Carbon.

Description of Steel.	Proportion of Carbon (approximate)*	Breaking Strain per square inch.	Elongation.
	per cent.	tons.	in.
No. 2	0.33	30.4	1.37
No. 4	0.43	34.0	1.37
No. 5	0.48	37.5	1.25
No. 6	0.53	42.5	1.12
No. 7	0.58	41.5†	0.81
No. 8	0.63	45.0	1.00
No. 10	0.74	45.5	0.69
No. 12	0.84	55.0	1.12
No. 15	1.00	60.0	1.00
No. 20	1.25	69.0	0.62

The elongation was measured after each addition of load in the scale at the long end of the lever, and that given in the table is the final amount of elongation, previous to adding the last cwt. in the scale which caused the breakage.

The Table shows that the tensile strength of the steel is increased by the addition of carbon, until it is combined with about $1\frac{1}{2}$ per cent. of carbon, when it sustains about 69 tons per square inch. But beyond this degree of carbonisation the steel becomes gradually weaker, until it reaches the form of cast iron, which sustains a tensile strain of only about 6 or 6½ tons per square inch. When the test bar is turned down at one point only, instead of through a considerable length, the result obtained has been found to be different; for a bar of steel turned down to $\frac{1}{2}$ in. diameter at one point only, did not break till the strain reached 79½ tons per square inch, whereas a bar of the same steel turned down to 1 in. diameter for $1\frac{1}{2}$ in. of its length broke with a tension of 60 tons per square inch.

Transverse Strength.—For testing, the transverse strength of the several varieties of steel, axles were made of the steel in the various degrees of carbonisation, which were subjected to the blows of a heavy ram until broken. The axles were all turned to 3.94 inches diameter at the centre, and 4.25 inches at the ends, and were supported on bearings 3 ft. apart; they were reversed at intervals when considerably bent by the blows of the ram. The ram weighed 1547 lb., or nearly 14 cwt., and was dropped on the centre of the axle from a height commencing at 1 foot, and increasing at each successive blow up to 36 ft. fall, unless the axle was broken at a previous blow.

Table II. gives the detail of the experiment on an axle of No. 4 steel, containing about $\frac{1}{4}$ per cent. of carbon; showing that it stood five blows of the ram falling from 36 ft. height before breaking, after twelve blows from the lower heights of fall, and the sum of all the deflexions produced by the blows amounted to 56 in.

* The intermediate figures in this column, from No. 4 to No. 15 inclusive, are merely approximate, being interpolated in proportion to the numbers of the steel.

† There was a flaw in this test bar, which will account for its breaking at a lower strain than the preceding number.

TABLE II.
Detail of Experiment on Transverse Strength of Axle made of No. 4 Steel.

No. of Blow.	Height of Fall.	Deflection.		
		Before Blow.	After Blow.	Effect of Blow.
	feet.	inches.	inches.	inches.
1	1	— 0.08	(0.19	0.19
2	2	(0.19	(0.53	0.34
3	3	(0.53	(1.12	0.59
4	4	(1.12	(0.00	1.12
5	5	(0.00	(1.19	1.19
6	7½	(1.19	(2.19	1.00
7	10	(2.19	(0.00	2.19
8	12½	(0.00	(2.19	2.19
9	15	(2.19	(0.75	2.94
10	20	(0.75	(3.00	3.75
11	25	(3.00	(1.50	4.50
12	30	(1.50	(3.81	5.31
13	36	(3.81	(2.37	6.19
14	36	(2.37	(3.75	6.12
15	36	(3.75	(2.31	6.06
16	36	(2.31	(3.88	6.19
17	36	(3.88	(2.25	6.13
18	36	(2.25	broken.	...
Sum of Deflections		... 56.00		

Table III. gives the general results of the series of experiments made in a similar manner to the above, with axles of the several varieties of steel; showing the total number of blows required to break each axle, the number that it sustained with 36 ft. fall of the ram before breaking, and the sum of all the deflexions produced. Three wrought-iron axles were also tried in the same way, one of the best fagotted axles that could be procured, and two scrap-iron axles.

TABLE III.
Transverse Strength of Axles made of Steel containing different proportions of Carbon.

Material of Axle.	Proportion of Carbon (approximate)*	Total Number of Blows.	Height of Fall in last Blow.	Number of Blows sustained from 36 ft. height.	Sum of Deflections.
	per cent.		feet.		inches.
Steel No. 2	0.33	17	36	4	58.81
" 4	0.43	18	36	5	56.00
" 5	0.48	18	36	5	53.56
" 6	0.53	15	36	2	35.06
" 7	0.58	16	36	3	58.81
" 8	0.63	18	36	5	46.00
" 10	0.74	16	36	3	40.31
" 12	0.84	10	20	0	8.56
" 15	1.00	8	12½	0	4.31
" 20	1.25	10	20	0	6.94
Best wrought iron.	...	13†	36	0	31.19
Scrap iron	...	5	5	0	2.00
Scrap iron	...	5‡	5	0	3.69

From these experiments it appears that, for bearing sudden and heavy blows, without regard to rigidity, the metal cannot contain too little carbon, provided it be pure and there be perfect cohesion of the particles. These qualities, however, cannot exist to the required degree in wrought-iron or puddled steel, as shown by the experiment with the wrought-iron axle in the above table; and are to be found only in cast steel, which must contain at least enough carbon to render it sufficiently fluid in melting. The steel-melting process alone can effectually rid the metal of the impurities that were contained in the iron from which it is made.

There is nothing more deleterious to iron or steel than overheating or too many heatings, and the writer believes that all welding affects the quality of the metal more or less injuriously. Cast steel has the great advantage of being less liable than any other metal in general use to become crystallised by vibration. It has already a natural crystal, and the result of the writer's experience is that its crystal can be changed into a weak form only by being overheated. Cast steel and Swedish wrought iron have been placed where they were subjected equally to continual blows, concussions, and vibrations; and the cast steel was found to stand for a long period without change of crystal, whereas the Swedish iron broke very soon, showing great changes in its form of crystallisation.

For most mechanical purposes the best material in practice is one that combines the power of resisting a tolerably high tensile as well as transverse strain; one that will bear a tension of about 45 to 50 tons per square inch will generally be quite strong enough, and will be below the point at which brittleness from too great rigidity begins. The following Table IV. gives a comparison of the preceding Tables I. and III., and shows that such a material is found in the steel Nos. 8 to 10, containing about $\frac{1}{2}$ to $\frac{3}{4}$ per cent. of carbon. There are, of course, purposes where a specially ductile or specially rigid material should be employed, but the latter should be used only in cases where it is not liable to be subjected to sudden concussions.

* The intermediate figures in this column, from No. 4 to No. 15 inclusive, are merely approximate, being interpolated in proportion to the numbers of the steel.

† Cracks began to show at the tenth blow, with 20 ft. height of fall, and increased at each subsequent blow.

‡ Two large cracks opened at the fifth blow, therefore it was considered practically broken.

TABLE IV.
Transverse and Tensile Strength of Steel containing different proportions of Carbon.

Description of Steel.	Proportion of Carbon (approx.)*	Transverse.	Tensile.	
		Sum of Deflections.	Breaking Strain per square inch.	Elongation.
	per cent.	inches.	tons.	inches.
No. 2	0.33	58.81	30.4	1.37
No. 4	0.43	56.00	34.0	1.37
No. 5	0.48	53.56	37.5	1.25
No. 6	0.53	35.06	42.5	1.12
No. 7	0.58	38.81	41.5	0.81
No. 8	0.63	46.00	45.0	1.00
No. 10	0.74	40.31	45.5	0.69
No. 12	0.84	8.56	55.0	1.12
No. 15	1.00	4.31	60.0	1.00
No. 20	1.25	6.94	69.0	0.62

The superior strength of cast steel cannot be better illustrated than by stating that castings of steel, without hammering, rolling, or other means of mechanical compression, show a very high degree of strength and tenacity, far above that of castings of any other metal in practical use. Advantage is taken of this property to make bells of cast steel, one-third lighter than bronze bells of the same diameter; and these lighter steel bells still bear double the breaking strain of the bronze ones. Another feature in the superior strength of castings in steel is that they are not so liable as other metals to break when subjected to concussions during intense frost, as proved by the fact that the cast-steel bells have been rung without the least injury in Russia and in Canada, when the thermometer ranged lower than 20° below zero, Fahr.; while the heavier and thicker bronze bells could not be rung in the same temperature without cracking.

The same properties have also led to the manufacture of cast-steel disc wheels with tyres in one solid body, for railway carriages and engines. One of these disc wheels was tested in the following manner. The wheel was put upon an axle fixed firmly in bearings at each end, and the ball, weighing 830 lb., or nearly 7½ cwt., suspended by an iron rod 2½ ft. long, as shown in the drawing, was drawn back and let fall so as to strike the wheel on the outside of the rim or tyre. The wheel was struck nine blows, increasing from 1 ft. to 14 ft. in vertical height or fall, after which the axle was so much bent that the ball could not strike the wheel. The axle was then straightened by striking the wheel on the opposite side, and was propped up to prevent bending again; and two more blows were struck from the height of 15 ft. and 16 ft., without causing any damage to the wheel.

The results of all the experiments that have been described show that cast steel, which even to the present time is considered by many a brittle material, fit only for a cutting instrument, is in fact a metal having not only all the good and desirable properties of wrought iron in a higher degree, but at the same time freedom from most of the objectionable properties of the latter, and admitting of being employed for every mechanical purpose where great ductility, tenacity, and transverse strength are required.

In reference to the specific gravity of steel as affected by the proportion of carbon it contains, chemists and scientific writers have generally given the specific gravity of steel as about 7.850, and of wrought iron about 7.650, that of water being 1; which leads to the inference that the addition of carbon to iron has the effect of increasing its density, and such is the general opinion at present. The contrary, however, has been found by the writer to be the fact, namely, that pure iron decreases in density the more carbon there is combined with it. The low specific gravity of wrought iron above stated must therefore have been obtained from common English merchant iron, a piece of which gave a specific gravity of 7.644, which very nearly agrees with that above mentioned; and must be owing to the impurities contained in the iron. The specific gravity of one of the purest and softest Swedish irons is 7.894; and that of the iron from which the steel was made for all the experiments that have been described above is about 7.860. Table V. gives the specific gravities as ascertained by experiment of the successive gradations of steel, from No. 2 containing about $\frac{1}{4}$ per cent. of carbon up to No. 20 containing about $1\frac{1}{2}$ per cent., the results having been all obtained with pieces of metal of considerable size, varying from 2½ to 4½ oz. in weight.

TABLE V.
Specific Gravity of Steel containing different proportions of Carbon.

Description of Steel.	Proportions of Carbon (approximate)*	Specific Gravity.
	per cent.	
Swedish iron, pure and soft	...	7.894
Iron from which the steel was made...	...	7.860
Steel No. 2	0.33	7.871
No. 4	0.42	7.867
No. 5	0.48	7.855
No. 6	0.53	7.855
No. 7	0.58	7.852
No. 8	0.63	7.848
No. 10	0.74	7.847
No. 12	0.84	7.840
No. 15	1.00	7.836
No. 20	1.25	7.823
Puddled steel, for melting purposes	...	7.824
Cast iron, mean of best authorities	2½ to 7	7.204

* The intermediate figures in this column, from No. 4 to No. 15 inclusive, are merely approximate, being interpolated in proportion to the numbers of the steel.

The specific gravities of the steel No. 2 and No. 4 are here seen to be greater than that of the original iron, but this may be attributed to the iron being freed from impurities in the melting. The conclusion, therefore, derived from the above figures is that every successive addition of carbon to pure iron renders the metal less dense, or diminishes its specific gravity.

ENGINEERING SCHOOL OF THE UNIVERSITY OF GLASGOW.

TO THE EDITOR OF ENGINEERING.

SIR,—The article on the above mentioned subject in your paper of the 18th is written in a friendly spirit, which must be gratifying to the members of this university; and it contains suggestions of much value, especially on the subject of descriptive geometry; but some of the remarks are obviously based on imperfect information as to matters of fact. You have apparently been led to believe that the majority of the students of engineering science in this university neglect to avail themselves of the instruction provided for them in natural philosophy, chemistry, and geology; that they come imperfectly prepared in mathematics, and they consequently fail to understand or to profit by the instruction given to them in the application of science to engineering. Such was the fact many years ago; but it is not so now. No student is allowed to become a candidate for a "certificate of proficiency in engineering science" unless he goes through a course of study in mathematics, natural philosophy, chemistry, and geology, prescribed by regulations which are printed in the *Glasgow University Calendar*. No student obtains such a certificate unless he goes through a satisfactory examination in these subjects, and also gives proofs of his skill in drawing. It is open to a student who does not intend to qualify himself for a certificate of proficiency in engineering science to attend as many or as few courses of lectures as he pleases; but a very small proportion of students belong to this last-mentioned class, probably not one-fifth of the whole. As regards the extent to which the students understand and profit by the instruction given to them, I may state that it is put to the test by oral examination, and by the issue of questions in writing at intervals of a week or ten days during the spring; that the value of the answers to the written questions is estimated by means of marks; and that, representing absolute accuracy and completeness by 1000, the mean value per student of the answers given by the whole of the students examined last session was 875.

I am, Sir, your obedient Servant,
October 22, 1867. W. J. MACQUORN RANKINE.

DIRECT COMMUNICATION BETWEEN THE METROPOLIS AND SOUTH WALES.

TO THE EDITOR OF ENGINEERING.

SIR,—I think that at the present time there can be no disputing the observations in one of your recent leading articles, that the necessity of a direct communication with the South Wales coal-fields is becoming almost daily more apparent; and it is in furtherance of meeting such a necessity that I venture to offer the following remarks, being, as I am, tolerably well acquainted with the localities in and through which I believe a better means of reaching South Wales may be opened up, than that at present existing.

It appears that inasmuch as the Great Western and South Wales Railways are both broad gauge, that the maintenance of such a gauge for the purpose in view is most desirable, as I will hereafter endeavour to show.

If it be possible, and I doubt it not, that a connecting link can be formed between the South Wales line from a point very low down the Severn and, say, Wootton Bassett on the Great Western line, avoiding thereby the circuitous route *via* Bristol, and the Bristol and South Wales Union line and ferry, the desired direct communication may be attained, allowing that it is far preferable to make use of existing lines at a comparative small cost, than to construct entire new lines at a very great and evidently unnecessary cost.

I have carefully considered the matter, and would suggest the construction of a loop line (which I will hereafter term the "South Wales loop") from Wootton Bassett, on the Great Western Railway, passing through or near to Malmesbury, Great Shinton, Chipping Sodbury (crossing the Midland below Yate), and Frampton Cotterell, to Patchway, on the Bristol and South Wales Union line, a distance, by my plans, of about 31 miles; the Bristol and South Wales Union line then could be used as far as Pilsning, from which place the Severn tunnel line, proposed by Mr. C. Richardson some three years since, would form a junction with the South Wales line at Rogiet. By these means there would be a direct through communication between London and South Wales without any break, and by broad gauge. The following is a comparison of the distances by present route with the one I suggest:

South Wales loop line.		
London to Wootton Bassett	...	84 miles
Wootton Bassett to Patchway	...	31 "
Patchway to Pilsning	...	3 "
Pilsning to Rogiet	...	7 "

Total ... 125 miles

By Great Western Railway *via* Gloucester.

London to Rogiet ... 149 miles

By Great Western Railway *via* Bristol.

London to Bristol ... 118 miles

Bristol to Rogiet by Bristol and South Wales Union line and ferry } ... 17½ "

Total ... 135½ miles,

giving in favour of the "South Wales loop" by first route 2½ miles, and by the second 10 miles.

The distances from Rogiet downwards I need not consider, as they, of course, remain unaltered. I take Rogiet as a starting point.

A double line of rails might be laid to Patchway, and from there to Rogiet, about 10 miles; a single line (at least for a few years) might be easily worked without offering any impediment to the traffic, thus avoiding for a time the increasing of the cost

where the works are heaviest, though I must own such a policy is not in reality wise.

The gradients, with two exceptions, would not be very severe, those in and out of the tunnel 1 in 100, and the over bank and tunnel, on the Bristol and South Wales Union line (already constructed), 1 in 70 or thereabouts. Between Patchway and Wootton Bassett I apprehend no greater difficulty than one short tunnel, and the gradients would be moderate.

The Box tunnel, and heavy inclines above it, would be entirely avoided.

I estimate that the cost of the whole works, loop line and tunnel, with and including seven stations, junctions, and telegraph would not exceed 1,600,000*l.*, being an average throughout of 42,000*l.* per mile.

I will now refer to a line, the "Great Western and South Wales Direct," already proposed, and which is to commence from Wootton Bassett, passing through the country parallel to the "South Wales loop," but higher up, *via* Tytherington, Wickwar, Thornbury, to above Aust Old Passage, crossing the Severn, and joining the South Wales above Chepstow bridge. It is not my intention to speak ill of this scheme, but simply to take it upon its merits in comparison with my proposed line; and first as to distances.

"Great Western Direct."

London to Rogiet.		Rogiet to Bristol.	
	miles.		miles.
London to Wootton Bassett	84	Rogiet to Chepstow	8
Wootton Bassett to Chepstow	35	Chepstow to Wickwar	12
Chepstow to Rogiet	8	By Midland to Bristol	15
	127		35

South Wales Loop.

Rogiet to Bristol *via* tunnel, 16½ miles, giving in favour of South Wales loop by No. 1, 2 miles, and by No. 2, 18½ miles.

And even if a line be constructed from Thornbury of the "Direct" line to Pilsning, which has been proposed, the distance to Bristol would be:

	miles.
Rogiet to Thornbury	14½
Thornbury to Pilsning	5½
Pilsning to Bristol by Bristol and South Wales Union line	9½
	29½

giving again 13 miles in favour of the "South Wales Loop," therefore in no instance can the "Direct" claim favour in point of distance; whether or not it does as to construction must be closely considered.

The question of crossing the Severn is perhaps a small "bone" for engineers, and it will be difficult to satisfy all parties as to which shall be the preferable method, by bridge or by tunnel, either is equally practicable, and can be constructed for single or double lines of rails. The cost of the tunnel may be admitted to be somewhat in excess of that of the bridge, but considering that the "Direct" route is two miles longer than the "South Wales Loop," that there are stringent Admiralty regulations to be encountered, as to height above high water, width of span between supports, and that the junction with the South Wales line is eight miles above that of the "South Wales Loop," I venture to think that the "tunnel" is the better method. Mr. Richardson made exceedingly careful soundings and surveys of the route he proposed, and I believe is very confident of its not being a work of extraordinary difficulty; it will be nearly or quite straight, approached by not over secure gradients, will form a junction as low down the Severn as it is practicable, the Admiralty overhead regulations will be escaped, and, although it may not be a work which would show so grandly as a bridge, yet it will be equally, if not more, useful than the bridge, and certainly as easy of construction. We have our Thames Tunnel, and, I hope, are to have a tunnel under the Mersey, and surely we can have one under the Severn.

If the Great Western and South Wales Companies would mutually consider and supply the line required, a really direct one, they would certainly preserve themselves from any competing opposition with such a line. No other company which has access to South Wales could possibly compete with them, and there is not the slightest doubt but that it would not only pay for itself, but materially assist the trunk lines.

I trust that you will deem my remarks worthy a small corner in your journal, if only for the sake of the opinions of interested gentlemen to which they may give rise.

As soon as I have completed my plans, I shall be glad to trouble you with some observations as to a communication with Southampton, in connexion with my proposed South Wales loop line and tunnel.

Your obedient Servant,
ARCHIBALD D. DAWNEY.

ENGINEERING EDUCATION.

TO THE EDITOR OF ENGINEERING.

SIR,—By way of making a few good suggestions to the council of the University of Glasgow as to the arrangements that ought to be made for the better and more comprehensive instruction of its engineering pupils, you take a cursory review of what has been done in various places on the Continent in this matter; and though it was not your intention specially to point out the good results that have been derived abroad from these institutions, your own conviction on that head, in so far as any rate as it regards the amount of scientific knowledge diffused, is clearly enough expressed in the paragraph where you say that "the majority of the pupils do not frequent the lectures of Sir W. Thomson; and do not understand those of Professor Rankine."

The fact, no doubt, is true enough, and having had good opportunities of watching the causes of the non-success of institutions of this kind when I fulfilled the duties of Professor of Engineering and Mechanics at the Queen's College in Liverpool, I have found that one of the proximate causes is the mercantile spirit with which the class of young men that frequent these institutions pursue their studies. I have invariably found that

these young men have no desire to make themselves masters of the general principles of the group of sciences which should constitute the technical education of the engineer, but that their object is to pick up from the lot particular and individual facts which they fancy will be especially useful to them in their individual pursuits, without troubling themselves about their correlation or co-ordination.

Its ultimate cause, however, is the great apathy, if not antipathy, which there is among the public at large, and among the professional public in particular, to foster scientific education for the sake only of the expansion which it gives to the mind, irrespective of all considerations of immediate gain to be derived from it; and I am not quite sure but that there are many professional men, and men in the trade, who view with jealousy the desire on the part of their young men of acquiring much knowledge of this kind, and who would do their best to discourage it. It would seem as though there was a fear on the part of these men, that the cultivation of science is likely to be productive of dangerous rivalry, and this opinion is fully borne out by the resistance which the Institution of Civil Engineers has lately made to the development of a kindred institution.

Shortsighted selfishness! for how different are the results in practice?

Having had occasion by intimate acquaintanceship to watch their development on the Continent (and as far as ten years back it was predicted to me that such would be the result), I find that the confidence inspired by a regular course of technical education has thrown the superintendence of most of the engineering works in the south of Europe and in Russia into the hands of the pupils of those institutions of the kind in question, which have earned for themselves a well-deserved reputation, and, as a natural sequence, the execution of those works has been thrown into Continental hands.

Where are our orders of locomotives and of bridges for the Spanish, the Italian, and the Russian railroads now? France and Belgium can tell; and the natural accessories of these, the workshop and other kind of plant, are going or have gone the same road.

Similar results are observable in establishments of a different kind; thus cotton factories are under the superintendence-in-chief of pupils of these institutions; and so it is with harbour works and other undertakings, not on account of the special, but on account of the general scientific education received, which enables the well-trained mind easily to apply general facts and principles to the particular wants of the moment. Cheapness alone will not account for the fact of the desertion mentioned, because with many drawbacks there still remain to us many great advantages, including that of facility of shipment and transportation; but preference has caused the balance of advantage to lean against us, and this would not have taken place in the same ratio, had this country enjoyed as high a reputation for its scientific institutions as its factories have for the excellence of their workmanship.

I trust you will persevere in the advocacy of of this important subject, and remain,

Yours very truly,
October 22, 1867. J. J. BIRCKEL.

THE RICHARDSON PROCESS.

TO THE EDITOR OF ENGINEERING.

SIR,—It was not my intention to trouble you with any further correspondence on this matter, but in justice to your readers, and for your own information, I beg to enclose you the analysis of two samples of iron made from the commonest Scotch pigs by this process. You will not fail to see that the sulphur and phosphorus are almost absent. The elimination of these two elementary substances is the most perfect of any case I have ever met with, or probably that has ever been effected by a practical manufacturing process from any kind of British ores. The results, you will find, completely bear out the theoretical views that have been advanced by Professor Abel and Dr. Percy, and upon which my original argument was founded. In the best makes of Lowmoor, Bowling, or Swedish irons, the sulphur and phosphorus are present variously at 0.104, 0.106, 0.15, and up to 0.3 per cent., whereas in iron that has been made from ordinary British ores by Mr. Bessemer's process the sulphur is as high as 0.5 per cent., and the phosphorus from below 1 to nearly 2 per cent. These facts combined with the unprecedented yield of, and short time required for making, malleable iron by Richardson's process are unquestionably advantages of the gravest importance to the ironmaster. It is perhaps rather singular that the silicon is not completely oxidised out of the metal; still there is no room to doubt that this will be effected with a stronger pressure of blast. It is eliminated in much greater quantity than in the best puddled iron, where its presence is usually somewhere above 0.1 per cent.

I am, Sir, your truly,
ST. JOHN VINCENT DAY.

Chambers, 166, Buchanan-street, Glasgow,
October 22, 1867.

(Copy) Analytical Laboratory, Surgeons' Hall,
Edinburgh, October 11, 1867.
Analyses of two samples of "Malleable Bar Iron" received from St. John Vincent Day, Esq., C.E., 166, Buchanan-street, Glasgow, and labelled, "New Process."

	Square bar.	Rod.
Iron	99.569	99.648
Carbon	0.035	0.031
Silicon	0.076	0.075
Sulphur	0.025	0.028
Phosphorus	0.031	0.034
Manganese	trace	trace
	99.736	99.816

The above malleable bar iron is exceptionally free from impurities, especially in relation to the sulphur and phosphorus, which are present only in comparatively minute proportions. The chemical purity of the iron betokens high mechanical qualities.

STEVENSON MACADAM, PH.D.

STEEL HYDRAULIC PRESS CYLINDER AND BASE-PLATE.

CAST BY MESSRS. VICKERS, SONS, AND CO., SHEFFIELD.

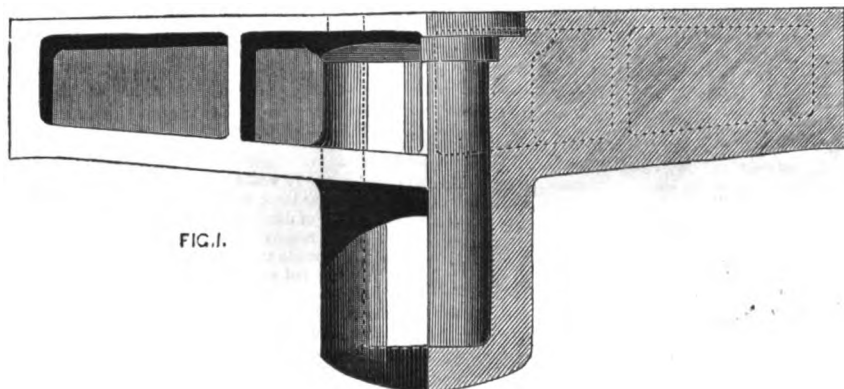


FIG. 1.

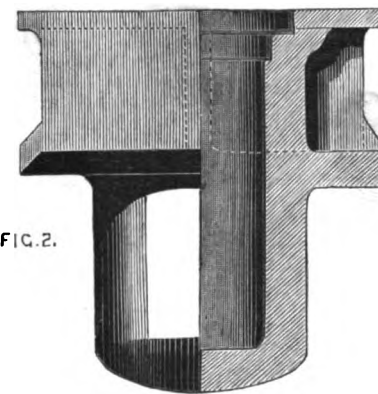


FIG. 2.

THE casting of complex forms in steel is a matter of considerable practical difficulty, and there are but few firms by which such castings can be turned out with any degree of certainty. On the Continent the Bochum Company have paid much attention to this class of work, and the locomotive cylinder cast in steel, and exhibited by them at Paris, shows the highly satisfactory results which they have obtained. In England Messrs. Vickers, Sons and Company, of Sheffield, have worked on the same system as that adopted by the Bochum Company, and they also have turned out a number of complex castings in steel. Amongst these is the hydraulic press cylinder and bed-plate of which we give an engraving above. This casting was produced thoroughly sound in a soft steel which is perfectly malleable. The cylinder is 8 in. in diameter and $2\frac{1}{2}$ in. thick, and from numerous and deep feathers the casting was one which it was difficult to produce perfectly sound in such a material.

PARSONS'S CARRIAGE AND WAGON WHEEL.

THERE have been, from time to time, many attempts made to introduce for the use of road-carriages wheels constructed wholly of iron, but these attempts have not been successful, as the rigidity of such wheels prevented them from being generally adopted. This objection, however, does not apply to wheels constructed of iron and wood in combination; and during the last few years wheels of this composite class, made on the plans illustrated below, have come into extensive use. These wheels—Parsons's patent, as they are called—are constructed as follows: The spokes consist of wrought-iron rods cast into the nave, this latter being made of a hard and tough quality of iron, and being strengthened by zigzag feathers cast around it. Before the felloes are put in place, a screw

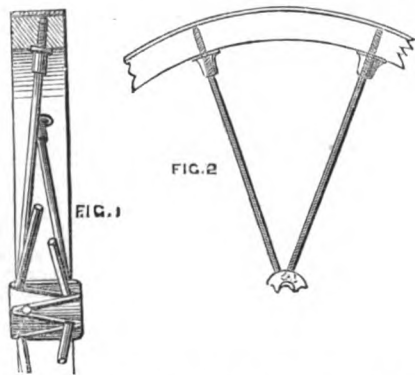


FIG. 2.

FIG. 1.

is cut on the end of each spoke, and small wrought-iron nuts or caps are then placed on the spokes, and screwed down as far as the screws are cut. The felloes have holes bored in them rather smaller than the spokes, and they are driven down upon the latter, so that they rest upon the nuts. The tyre is then shrunk on in the usual way. The wheel is stiffened by the spokes being alternately inclined to the plane of the wheel in opposite direction.

The advantages claimed for this form of wheel are, amongst others, that there is no shrinkage of the wheel, and consequent loosening of the tyre, that the felloes are not weakened by the cutting of large mortises in them, and that as the boss itself forms the bush, it can be made shorter than in wooden wheels, where a certain length is necessary to prevent the bush from working loose. This shortening of the boss correspondingly shortens the axle-arm, and renders it less likely to break off at the shoulder; and it also lessens the projection of the boss beyond the plane of the wheel. The fact of the wheel not being influenced by moisture renders it peculiarly adapted for water-carts, and very many corporations have already adopted it for these vehicles. Amongst others, the Brighton corporation have fifty pairs, and the Liverpool corporation a dozen pairs at work. At first Mr. Parsons met with considerable opposition from the London wheelwrights; and as most of them even now refuse to re-tyre or re-felloe his wheel, he has been compelled to make arrangements for the carrying on of those operations in London. The wheels are being manufactured by the West of England Engineering and Coker Canvas Company, of the Parrett Works, Martock.

STORER'S DIGESTER AND LUBRICATOR.

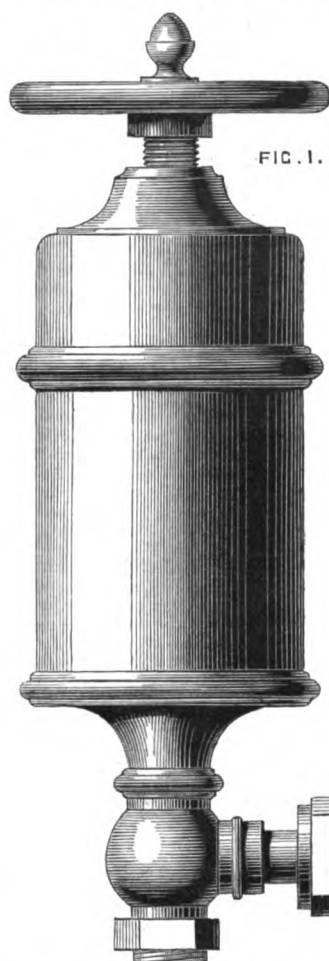
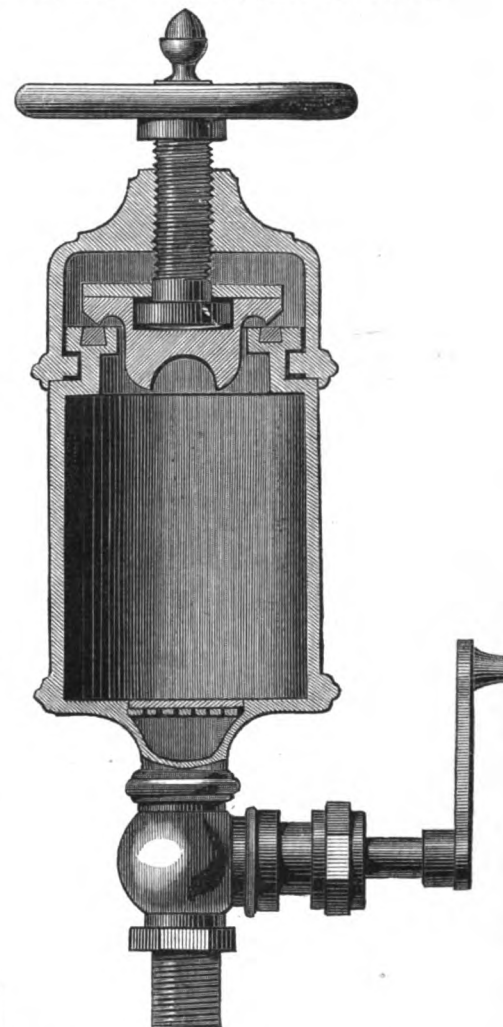


FIG. 1.



THE very simple digester and lubricator, of which we annex engravings, is one which has been designed by Mr. John Storer, of Birmingham, for the purpose of enabling suet or animal fats to be effectually employed as lubricants for the cylinders of steam-engines. It frequently happens that the working parts of engines become corroded from the action of the acids contained in many kinds of oil used for lubrication, acids from which suet and rough fat are entirely free, as they also necessarily are from other adulterations. In Mr. Storer's lubricator the suet or fat is placed, in the solid state, in a chamber or reservoir into which the steam is admitted through a pipe connecting the lubricator with the steam-pipe or valve-chest of the engine, this pipe also serving to conduct the lubricating material to a point where it is taken up by the steam. At the bottom of the reservoir is a grating which prevents the passage of any portion of the lubricating material which is not perfectly liquified. The top of the reservoir is closed by a cover, which forms a perfectly steam-tight joint, and which can be removed or replaced in an instant by merely turning the hand-wheel at the top through one revolution. It will be seen by the section that the cover of the chamber has a V-shaped rim formed on its underside, and this rim beds on a ring of soft metal recessed into the top of the reservoir. The cover is pressed down on its seat by a screw, which passes through the brass cap by which the top of the lubricator is covered, this cap being connected to the main body of the lubricator by studs taking into recesses in the latter, and being capable of being released by being merely turned partly round.

In charging the lubricator, the perforated strainer is covered to a depth of about 1 in. with cotton waste, and the suet or rough fat is then put in without any previous preparation. The top of the chamber is then put on and secured, and the cock on the pipe connecting the lubricator with the engine opened. No further trouble or attention is required; the suet or fat is melted gradually by the action of the steam, and as it melts it runs down and lubricates the steam on its way to the cylinder. The lubricators are generally proportioned so as to hold a charge sufficient to last ten or twelve hours. The lubricator may, if preferred, be placed on the cylinder itself, but it is found that the lubrication is performed far more effectively if the lubricator is connected to the steam-pipe. It is found that any skin, &c., which may be mixed with the rough fat is perfectly "digested," or dissolved by the action of the steam, and any dirt or grit that may accidentally have become mixed with the lubricating material is kept back by the cotton waste. Mr. Storer's lubricators have been largely applied in America, and they have been found to give excellent results. They are now being made in this country by Messrs. Tangye Brothers, of Birmingham, who have thoroughly tested them on their own engines, and have found them to answer their purpose perfectly.

APPARATUS FOR TRANSPORTING HEAVY MASSES.

DESIGNED BY M. VASSIVIÈRE, CONTRACTOR, LYONS.

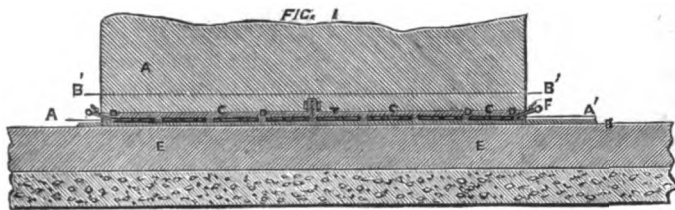


FIG. 2

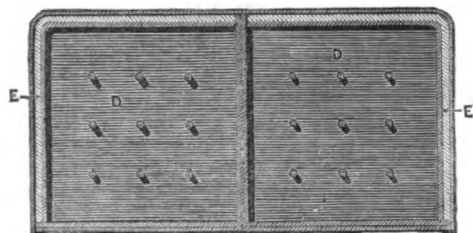
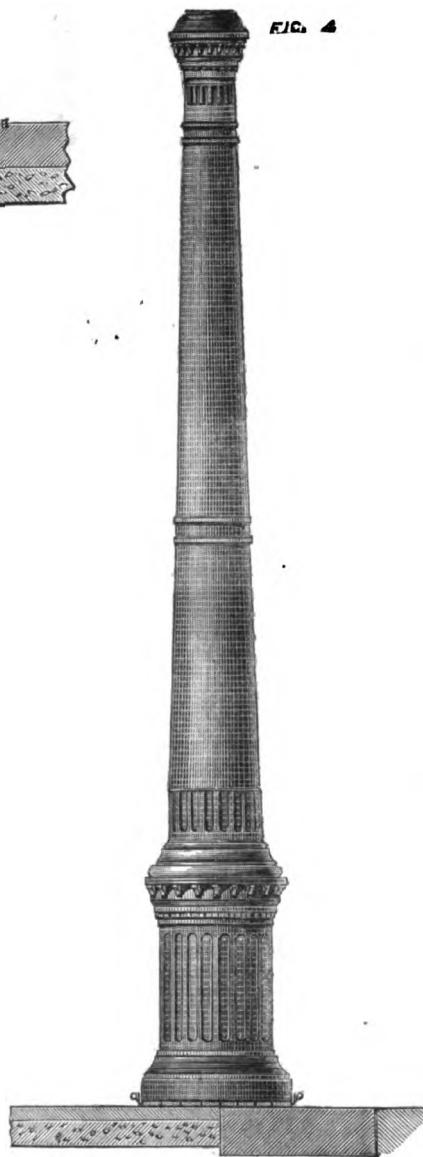
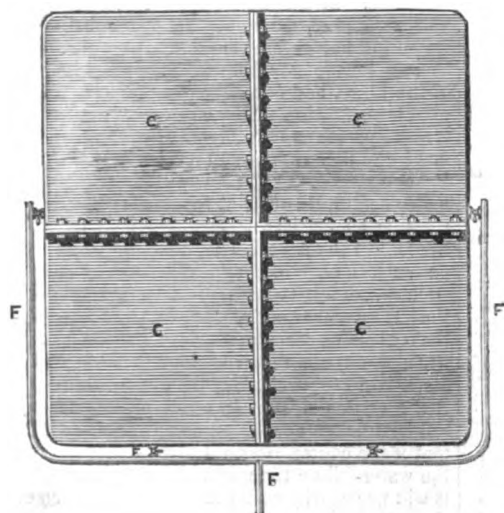


FIG. 3



WHEN a necessity arises, as it not unfrequently does, for shifting a heavy structure, such as a chimney, from the site which it occupies to another not far off, there are two methods in which the change of position can be effected. The one is to take down the structure and rebuild it on the new site, and the other is to transport it *en masse*. Of these two systems the latter is frequently the preferable one, on account of the saving of expense effected by it, and it has consequently been adopted to a considerable extent, particularly in America. Amongst the appliances which have been contrived for facilitating the transport of heavy blocks in this way is that of which we annex illustrations, and which has been designed by M. Vassivière, a contractor of Lyons, who exhibits it at the Paris Exhibition.

M. Vassivière's method of shifting heavy structures, monoliths, &c., consists in interposing at the point where the block to be moved is separated from its base, two surfaces capable of sliding on each other, the upper surface extending over the whole of the base of the object to be shifted, and the lower one not only extending over the same area, but reaching to the new site which the block is to occupy. The surfaces are put in place by underpinning the structure, and they may be introduced in sections and joined together afterwards.

The upper surface is, by preference, of metal, and is slightly hollowed out on its under side, so that it forms a series of chambers, and only bears on the lower surface at the sides where it forms a tight joint and at the points where the divisions between the chambers occur. The surfaces having been put in position, water is forced into the chambers—either into all of them simultaneously, or into a few of them situated symmetrically—and this water, not being able to escape around the edges, exercises a powerful lifting pressure over the whole area of the base. This having been done, it is found that the structure can be shifted horizontally with but comparatively little effort, the mass almost floating on the interposed film of water. When the mass has been shifted the required distance, the water is let out of the chambers and the latter filled in with cement.

In our engraving, Fig. 1 is a vertical section of the apparatus as applied to the base of a factory chimney, and Fig. 2 is a corresponding horizontal section, whilst Fig. 3 is a plan of the upper surface, and Fig. 4 an elevation of the chimney with the apparatus applied to it. In these figures, A is the mass to be removed; B is the lower surface, constructed of

metal or other material sufficiently smooth; and C is the upper surface, made of metal in four sections, which are united by bolts. DD are the points of contact of the two surfaces, and E is the packing by which the tightness of the joints is secured. The water is introduced into the cells through the pipes, F.

NOTES FROM INDIA.

No messages containing figures are to be received for the future Indo-European telegraph, unless they also specify the stocks to which they refer.

A Calcutta paper states that petroleum has been discovered in the Bengal Presidency, and that 5000 gallons of it has been already shipped to Calcutta.

On the evening of 3rd September, thirty-six pontoons of the bridge at Cawnpore and the two boats next them were carried off, and of these seventeen were stranded on a bank a mile and a half down the river, and in the attempt to get them back four were sunk. Passengers and goods are now ferried over by boats. It is said the Indian Branch Railway Company are negotiating with Government for a permanent bridge, which can be completed for less than 200,000*l*.

The reports of the cotton crop in the Central Provinces and Khandeish are very favourable, the area under cultivation in the district being estimated at about one-fourth more than last year. In the Ahmedabad district (Gujerat) the crop does not promise favourably, owing to the lateness of the rainy season. Energetic exertions were being made to complete the road on the Arbye Ghaut which connects the cotton districts of Dharwar with the part of Karwar. Many cotton-dealers have promised to send their exports this season direct to England from the fine port of Karwar.

A correspondent, writing from Rajpootana, informs the *Bombay Gazette*, that the Nawab of Tonk has recently been fortunate to discover some very valuable and useful mines in his territory. A stone of extraordinary quality was discovered in Ashaquadbad, near Mahomed Abad, which, on being examined, was found to answer the purpose of a lithographic stone. The correspondent, who had the opportunity of seeing papers printed from these stones, describes the printing to be equal in every respect to that of ordinary stones. At Purgunah Ally Gurh a mine of iron of a superior description has been found, to the great joy of the Nawab; and at Rehem Abad, cornelian stones have been found in such abundance as to cover the surface of

the ground to a great extent. These cornelian stones, bright in colour, resemble camphor in whiteness, and are found in layers. Again, on the hills of Hatsura, four rooses distant from Tonk, on its eastern corner, a mine of bright and transparent crystal has been discovered. All these fortunate circumstances will doubtless tend to enrich the Nawab, and are calculated to enrich his extensive territory.

The Ceylon Railway was opened for goods traffic to a limited extent on 16th September last, but great doubts are entertained of its proving so useful to the planters as they expected, under present arrangements. The charges are seemingly too high, and the inconveniences attending railway transport great; but the former will doubtless be modified after some time, and numerous private carrying agencies have been started to obviate the latter.

In the Ceylon Legislative Council it is stated that education and irrigation questions will largely occupy the attention of the legislators. There is the usual interest awake in the planting districts respecting the votes for public works and new roads, while the public generally are anxious to learn if any steps are to be taken shortly in connexion with the Gampola Railway Extension. The forthcoming scheme for the encouragement and extension of irrigation works has occupied a good deal of public attention.

A correspondent of the *Delhi Gazette*, writing of the death of Major Fuller, blames Government for not having viaducts across those dangerous streams. Some years ago an engineer officer proposed to build over them, but was succeeded in the station by incompetent officers, who, with a view to saving expense, built the causeway instead, which has led to the present disastrous accident.

The *Englishman* states that the following points have been recommended as distinguishing the line to be followed by the Burmo-Chinese Railway within the British territories. From Rangoon to Pegu, thence to a point on the Beehrig river near the village of Pello, and from Pello to the Pali Choung, a stream which flows into the Salween, and is the boundary of the Anglo-Burmese dominions in this direction.

THE COTTON TRADE.—The average weekly deliveries of cotton from Liverpool to the trade, to October 18, this year were 45,630 bales, as compared with 45,180 bales to the corresponding date of 1866, and 38,860 bales to the corresponding date of 1865. The average for the whole of 1866 was 45,460 bales. Speculative operations have been greatly curtailed this year: thus the quantity taken on speculation to October 18 this year was only 161,320 bales, as compared with 333,800 bales to the corresponding date of 1866, and 780,400 bales to the corresponding date of 1865.

FRENCH LOCOMOTIVES.—A steamer has left Havre, having on board a number of large locomotives for Russia. It was reported some time since that the Creusot works had received an order for eighty locomotives for Russia; it does not appear, however, that the affair is quite definitively concluded. The pecuniary assistance proposed to be afforded by the Russian Government this year to the work of railway construction in Russia is rather more than 3,000,000*l*.

AN AMERICAN RAILWAY UNIFORM.—The New York Central Railroad Company is preparing to uniform its *employés*, in accordance with the act of the last Legislature. The conductors will wear coats and pants of dark blue pilot, beaver, or broadcloth, the coat trimmed with brass buttons. The cap will be of blue cloth, with two bands of gold lace, the lower band to be an inch and a half in width. The brakemen will probably wear a "regulation" cap only for the present.

MIDLAND RAILWAY.—The extension of this system to Barnsley is being vigorously carried forward. The works are rather heavy, comprising as they do a viaduct (near Hoyle Mill) of thirteen openings, ten of them 60 ft. in length, two 96 ft., and one 36 ft. The maximum height of this viaduct from the ground is 86 ft., and the estimated cost of the work is from 30,000*l*. to 40,000*l*.

COAL EXPORTS.—The quantity of coal exported from the United Kingdom to August 31 this year was 6,715,439 tons, as compared with 6,690,349 tons in the corresponding period of 1866, and 6,095,515 tons in the corresponding period of 1865. The average price of each ton exported was 10*s*. 4*d*. to August 31 this year, as compared with 10*s*. 14*d*. to the corresponding date of 1866, and 9*s*. 6*d*. to the corresponding date of 1865.

A PROMISING SCHEME.—A certain M. Boulet is, we understand, endeavouring to get up a company for the construction of a bridge across the English Channel. It is to be a girder bridge, the piers being constructed of piles which are to be carried down to the bottom of the Channel, and are to have enormous buoys attached to them to assist them in carrying their load! Fancy!

NEW SMALL ARMS IN PRUSSIA.—The Prussian Government is said to have adopted for trial a new kind of musket firing an explosive projectile. This is called the Dreyse musket. It is of large bore, 21 millimetres diameter (or about 0.82 in.), and the projectile is made up with the charge in a paper cartridge containing the percussion powder in a small papier mâché cap at the centre of the base of the cartridge, so that it can be fired by any central fire breach-loading system. The projectile is of cast iron, egg-shaped, 53 millimetres long, and 19 millimetres in diameter, requiring a disc wad to hold it in its position in the barrel, which has a larger bore by 2 millimetres. The total weight of the bullet is 88 grammes, including the weight of 2½ grammes of fine powder with which it is filled. The entire cartridge weighs 79 grammes (six or seven cartridges weighing 1 lb.), the length of the cartridge is 85 millimetres. The bullet is provided with a percussion fuse somewhat similar in principle—but smaller in size than—the Armstrong or Boxer fuses—now employed for artillery projectiles, and the intention of this arrangement is to make each bullet explode and fly a second time after it has struck the ground or any other impenetrable object. It is said that the effect produced by the explosion of the projectiles is very powerful, and that it is particularly likely to spread terror in the ranks of infantry to see the enemy's spent bullets rise up with an explosion at their feet, with an increased chance of damage and destruction.

INDIAN PROFESSIONAL LITERATURE.

How much longer, we wonder, are engineers at home to be kept in ignorance regarding the great public works designed for, or being carried out in, the vast peninsula of India? We ourselves, it is true, derive much information on this subject; but then that is obtained from an exclusive source, and from one to which the profession generally cannot have ready access. The library at the East India Office may be searched in vain for any collection of such works, and the shelves in the reading-room belonging to the Institution in Great George-street contain but a very few volumes of them, and what are there are mostly of an old date. It is well known that very many useful and valuable reports, and collections of papers known as "Selections from the Records of Government," are constantly being published in India, at each of the three Presidency Towns, besides which numerous other papers of professional interest are annually issuing from the several Government presses in India. If these and all documents of a like nature relating to India and her public works could be collected together in this country, what a fund of information might there not be gleaned from them; and how invaluable would not such a collection prove, could it but be thrown open so as to be available for the purposes of study to aspirants for future honours as engineers on the vast plains of our eastern empire! The differences that exist between the nature of engineering operations in this country and in India cannot be learned, under present circumstances, by any neophyte whilst pursuing his prescribed three years' course of study, in order to gain admission to the annual competitive examinations held at the India Office; and on his arrival in India, the character of the soil, the nature of the rivers, and the peculiar characteristics of their tides and streams, and, more particularly, the first principles of irrigation as practised there, are all subjects regarding which he has to commence his education. The reason for all this is, that most useful books on such subjects published in India are issued from the Government offices; but few copies find their way to this country, where the sale of such books must needs be limited, and the home authorities, if they ever receive copies of them, keep them in true conservative seclusion, neither distributing them amongst the few professional libraries that do exist, nor endeavouring to diffuse the useful knowledge they contain, by the establishment of a Public Works Library at the India Office, which should be open during official hours, for the convenience of all desiring to improve their knowledge regarding the great works which are constructed by the Government for the purposes of developing the vast and hidden resources of those territories, to which they succeeded after the outbreak of the Indian mutiny.

What would be thought, we should like to know, of a person possessed of certain information, and of which he was unable to make practical use, who refused to part with it that others might derive advantage from that knowledge which he was not in a position to employ? Yet such is the present position of the Indian Government. We should have thought that the importance of civil engineering works to the economy of imperial Government was sufficiently well understood by all; and with reference to their importance to India, we should truly be glad to see a little more of the engineering element represented in the India Council at home. That Council possess, at present, but one officer of the Royal Engineers, and another, who, though an old artillery officer, distinguished himself principally by the construction of one of the finest hydraulic works in the whole of India.

Can it be that the idea of making a practical use in this country of Indian professional publications has never presented itself to the minds of the Governments either at home or abroad? If so, we would beg to be permitted to point out, not only how great a benefit would thereby be conferred upon the profession at home, but how much greater benefit would probably accrue to the Government itself, by furnishing a source of information which at present does not exist in this country, and which would most unquestionably be gladly taken advantage of by engineers, but more especially by those who, fate has decreed, shall find their fields of employment in India. And thus would the home Government, without any actual and direct outlay, be furnishing a most important means of education to those who are hereafter to direct the execution of its public works abroad.

BELGIAN COAL.—During the first eight months of this year the exports of coal from Belgium amounted to 2,187,000 tons, as compared with 2,508,207 tons in the corresponding period of 1866. The French market has become almost the sole foreign outlet for Belgian coal.

FORESTS IN INDIA.

IN a recent article we referred to the necessity of maintaining the forests in India, with a view to furnishing the necessary supplies as fuel for the railway locomotives; but in addition to this there are other causes, even more important to the welfare of the empire, which render the destruction of her forests a thing to be reprehended, the principal effects of which have been proved to be a very serious interference with the natural water supply of the country. Such a diminution of the supply of water over many parts of Bengal has recently been brought to the notice of the local Government by Mr. Chapman, who considers that much of the evil is due to the growing subdivision of property; that the denudation of forests has greatly increased the risk of famine, and that to the deterioration in the quality as well as quantity of water much of the epidemic fever, which has wasted lower Bengal for years, may be considered to be due.

The subject having thus been prominently brought forward, we cannot permit it to pass by without a word or two of comment. The subject of the destruction of forests as affecting the water supply in India was brought before the Royal Geographical Society by its secretary, Mr. Clements R. Markham, F.S.A., in a paper read before them by its author on 11th June, 1866, soon after his return from an official visit to that country, in connexion with the growth of the quinine-yielding chinchona, which, we believe, that gentleman was the first to introduce into India.

"The destruction of forests," says Mr. Markham, "has been one of the chief agents in effecting 'changes in the earth's surface, and the best methods of counteracting evils which may be caused by these 'excessive clearances is one of the most important 'questions that occupy the attention of physical 'geographers.' This agency, it appears, is now at work in the Western Ghats of India, amongst which are the sources of many of the mighty rivers which water the plains of the peninsula. There is a notable difference between the climate on either side of these ghats. On the west side the slopes are abundantly watered by the south-west monsoon, and the streams fall into the backwater, supplying the narrow strip of land with water in abundance. On these Travancore hills clearing may be carried on to any extent, without detriment to the low country, which could well dispense with some of its surplus moisture. But on the east side the due supply of water for the tanks and channels is a necessary of life to the people inhabiting the wide plains of Tinnevely. Indiscriminate felling on the eastern slopes would lead to most deplorable results, and the evil is already beginning to be felt; further grants of land have been prohibited in the Tenkassy Talug, and in Nanganary the people complain bitterly of the drying up of the streams.

The rainfall along these Western Ghats is derived almost entirely from the south-west monsoon, and consequently nearly the whole of it is deposited between the months of May and September; and it is worthy of note that the amount of rainfall along the ghats decreases as Cape Comerin is approached; thus at Mahabaleshwar, near Bombay, it is 248 in., while at Trivanderum, the capital of Travancore, it is 65 in., and at Cape Comerin itself it is only 30 in. Within the last twenty years an English colony of planters has been establishing itself in the mountain districts of the Indian Peninsula, the formation of which has given rise to a wide-spread destruction of the primeval forest. The planters are occupied chiefly in the cultivation of coffee, tea, and the quinine-yielding chinchona; and these give rise to the felling and clearing of forests, in the formation of plantations, and a total area of little short of 60,000 acres of forest has thus been already destroyed. Nor has the process by any means reached its limit; and a great change is taking place in the physical condition of the hill districts. One obvious consequence of the destruction of forests is an increased rapidity of surface drainage, giving rise to sudden and destructive floods at the outlet on the plains, where the change of slope causes a diminution of velocity, and to injurious freshes in the irrigating rivers after they have reached the plains. The effect of vegetation is undoubtedly to retard evaporation, and to check the rapidity of drainage; and the removal of forests of course has an opposite effect. The hill districts of India are now affording proofs of this law of nature. The floods caused by the monsoon rains are yearly increasing in size and violence. During the monsoon of 1865 two floods swept down the gorge at Coonoor, in the Neilgherries, doing much damage, and they were of a volume such as had never been known before. In 1863 the bridge of the Mootramuddy at Coorg was swept away by the floods. Plans were

drawn up for a new bridge which should be out of reach of all future floods; but in the following year they rose to a greater height, and in 1865 higher still. More recently we have the floods of the present season, which have caused so much destruction to the bridges on the Great Indian Peninsula and the Bombay and Baroda railways. All this is clearly due to the extensive clearance of forests, owing to which the rain-water rushes off the surface instead of sinking into the earth and forming springs.

For the last twelve years, a system of forest conservancy has been established in the Madras Presidency, with a view mainly to the preservation of valuable timber and of firewood, and to the retention of belts of forest near the sources and along the courses of streams. As a branch of the Public Works Department, a forest agency is very necessary, both for the supervision of selling and planting on a proper system, so as to ensure an adequate supply of timber for public works, and of fuel for railways, and for the conservancy of forests, to obviate the disastrous effects of indiscriminate felling on bridges, roadways, and irrigation works.

In almost all countries there is either something to check the rapid flow of the rain-water in surface drainage, or else there are disastrous floods. This agency acts as a sponge. It consists either of a large area of forest, or of swamp, or of peat-bog, or of a system of lakes or of artificial reservoirs. In Yorkshire the sponge was provided by the undrained moors of the North and West Ridings. As these moors are drained, the safety-valve is removed, and the heavy floods of the autumn of 1866 are the immediate consequence. If the moors are completely drained, artificial reservoirs, must eventually be substituted, or the floods will be a chronic and increasing evil. In France there is no sponge of any kind to regulate the waters of the Loire, and consequently there are frequent and disastrous floods; while, on the Rhone, the Lake of Geneva performs that important duty, and hence the floods are less violent and not so frequent. The river Po and its numerous affluents are always completely under control, because, at the head waters of each river, there is an efficient sponge provided by the lakes at the foot of the Alps. The river Ebro, in Spain, has no such moderator, and destructive floods in the country round Tortosa are therefore frequent. On the Western Ghats, the sponge is furnished by the extensive forests which clothe their sides; and when these are removed to any great extent, it is essential to the welfare of the whole peninsula of India that a system of storing water in large reservoirs or artificial lakes should be substituted. Thus we see that if the course prescribed by nature, for restraining the water-fall on the mountains in India, be followed, it will necessarily result in the maintenance of forests along their slopes; and as the older plantations are cut down for fuel, or other purposes, they must be replaced by others, in order to maintain a sufficient equilibrium of forces for the restraint of the rain waters and prevention of floods. The alternative of catching these flood waters in artificial reservoirs, and so preventing them from rushing headlong down upon the plains, will form the subject for a separate article in a future number.

BRITISH ARTISANS' VISITS TO PARIS.—Mr. J. T. Dexter the corresponding secretary of the Paris Excursion Committee, has addressed the following letter to the editor of the *Times*: "Sir,—It seems to have been positively determined by the Commission for the Universal Exhibition, at the meeting on the 13th inst., to close the building officially on the last day of the present month; allowing, however, the director of the Exhibition, M. Le Play, to open it to the public ten days longer at a half franc for each admission, and seven days longer without charge. If the railway companies are alive to the opportunity, large numbers of persons who have not been to Paris, and now all but despair of going, may still be enabled to examine the most perfect collection of the products of industry for which this age of exhibitions has yet given place. I trust the occasion will not pass unheeded. Engaged in the work of facilitating the visits of British workmen, I have had little leisure to examine for myself the vast resources within the building in the Champ de Mars. But the testimony of men whom I am bound to regard as qualified to pronounce upon such matters is given with all but unanimous consent to the verdict that, judged by their work, the French artisans are outstripping our own more free and hardy workmen not alone in taste and delicate manipulation, but also in solid workmanship and skill. To mark this condition, and to ascertain the causes which have conducted to it, is nothing less than our duty. A hint of this kind may be in better time than a long discourse; so I will simply add that if the railway facilities be extended this committee will not yet bring its operations to a close."

WHAT NEXT?—An American genius has arrived in London with a most miraculous breech-loading gun, the invention of which he solemnly asserts was communicated to him by two spirits of the departed! He is now en route for Paris to exhibit this new wonder in the shape of a death-dealing instrument to the emperor.—*The Cosmopolitan*.

THE SOCIETY OF ENGINEERS.

W. H. LE FEUVRE, ESQ., President, in the Chair.

October 7, 1867.

The Quality of Iron as now Used. By EWING MATHESON.
(Continued from page 378.)

AND now there having been established at any rate a *prima facie* case, two things may naturally be demanded—that it be shown what harm results from the present state of things, and then what suggestions can be made for a remedy.

Whatever may be the different inferences drawn from the fact, the fact itself is patent to all that in the various iron-fields in this country, and in the different iron-making districts, there is the greatest diversity in quality. It is no use grumbling at what nature has done; but any evils that are likely to result should be provided against and combated. This is not the case, for, as before stated, the fact is practically ignored by a great proportion of engineers. The irons from different furnaces varying to so great a degree, it would be imagined that record would be kept of the comparative values, that some public tables of reference would exist, that some public body, such as the Society represented here, would give authoritative and impartial standards of excellence for guidance and reference. But at present such is not the case; and when work, great or small, is competed for, ironfounders from Yorkshire, Derbyshire, Newcastle, and Glasgow send in tenders, which are examined with but little reference to anything but price, and the work is given out with an utter disregard of the enormous difference in quality that may have been intended by the various competitors, though certainly there may be specifications containing such vague phrases as "the iron is to be equal to good grey Staffordshire," or some indefinite statement of that kind. In deciding upon the manufacturer, has the engineer tried to imagine whether Scotch, Yorkshire grey, hematite, and Derbyshire are in favour with the founder, or whether Cleveland pigs and burnt firebricks are waiting to be melted for him? And yet it just means a difference in value of from 5 to 30 per cent. in the strength and toughness of the castings, for, by the manner in which specifications are now framed and enforced, differences to that extent are quite possible, and the only reason to be assigned for such a state of things is that engineers do not realise sufficiently that so great a diversity in quality exists. They seem only too ready to assume that cast iron is always about the same, and that certain formulæ in standard text-books are sufficient for their purpose, while really the data there given are taken from experiments made years ago, and only give a safe average value that may be enough for students, but which has too great a margin above and below to be all that should content a professional adviser in such matters.

It may be said that in cast iron an increase of section will cover any deficiency in quality, and make all safe. To a certain extent this is so; but that it is a dangerous and wasteful plan may be demonstrated. In increasing the section of a column or girder the same increased ratio of strength is not obtained; for, beyond a certain thickness of cast iron, the value per square inch of section rapidly decreases. Let the strong girder or stanchion, A, be compared with the still stronger ones, B. It will be found that the grain of the metal in the former is equal throughout, but not so in the latter. The iron, cooling first at the outside, solidifies and contracts, while that in the inside forms much larger crystals, and the open granulated appearance can be easily noted; and if the thickness were still more increased, there would soon be found the honeycomb appearance of an unsound casting, and perhaps even a large hole. Columns are certainly made hollow by preference; but if it were attempted to cast them solid, they would be formed with a hole down the middle for all that. There are lying here two fragments broken from the same railway chair. In the one, the little triangular core space is observed, and the metal around it is close; in the other, the little core has been omitted, and the weak open grain is discernible. If a column were made of 3 in. metal, and then had 1 in. turned off inside and out, so as to leave 1 in. thickness, it would be utterly valueless, so inferior would be the metal left. In exaggerated cases, attention has always been given to this, and in the thick cylinders that are made for hydraulic presses every engineer knows how difficult it is to counteract this tendency. Even after casting an enormous head of metal on the top, there is still a risk of spongy iron, the section discloses very large crystals, and even with iron 6 in. thick the water forces its way, and the moisture exudes, like perspiration, on the surface. And not only is it to a certain degree dangerous to rely on increased sections to make up for inferior iron, but it is wasteful to all concerned. The best iron (that used to obtain the highest figure of excellence just given) costs 20s., or more, a ton more than the very cheapest that can be obtained. But assuming that in practice the good iron is mixed with a little of an inferior kind, and that the very bad has a little good infused into it to redeem it from its worse condition, the difference may be taken at 10s. to 15s. But fuel costs the same, the moulding is the same for both, and the labour in lifting and carrying is greater for the heavier section, and of course freight is dearer, too, so that it will almost always be found that it would be cheaper to use a high quality of iron. Supposing a saving is effected of 1 per cent., or 10 per cent., the iron obtained is, say, 400 of the standard instead of 500, a distinct loss of 20 per cent.; to which must be added another 10 per cent. for extra weight incurred for safety's sake; so that in all 30 per cent. loss stands against 10 per cent. of apparent gain—surely a miserable attempt at economy. And not only is this a mistake to the buyer, but to the manufacturer. Some founders think the free-and-easy way the best, and are not at all displeased to see heavy sections employed, and big castings demanded; other men, who see how their use of good iron is unappreciated, are tempted to do like their neighbours; while many see with regret that cast iron is in a manner falling into disrepute. Already have surveyors in London and elsewhere reported against the very extended and exclusive use of it to so large an extent in new buildings. There is also a growing inclination to make certain things of wrought iron that could be made cheaper in cast, and men are taxing their ingenuity to produce cast malleable iron, and are trying queer mixtures of pig and wrought scrap combined for castings, while really the best and toughest

cast iron would quite fulfil their purpose. And in some cases of this sort, for light and ornamental work, the difference in cost of material would be utterly inappreciable.

This paper is being addressed to engineers; at any rate, appeals to those who can discuss the facts put forward, and, if they think proper, act upon them; but unfortunately a large proportion of constructive ironwork is not designed by engineers at all, but by architects, who, of necessity, have to usurp functions in the proper exercise of which they have not had sufficient experience. The materials of wood and stone and brick they use in all the forms and dispositions which the accumulated traditions of centuries have proved to be the best, and they have on every side examples of what to copy or avoid; but iron is a new element to many of them, in its present numerous varieties of application. The demand for fire-proof building, for open spaces involving large distances between bearings, in fact, for iron in most of its modern forms, finds many of them quite unprepared for its proper treatment. There are, of course, many exceptions; there are those who have wisely given the subject special attention, as one which is paramount; and there are those who, in these special matters, show their discretion by asking the advice of an engineer. But while some architects have a large and happy belief in the capabilities of iron, they cannot get out of their mind's eye, or rather their architectural eye, the forms and proportions of bygone days. There is sometimes to be seen in London the most extraordinary strength given to ironwork in warehouses, where stanchions have been placed, that would have carried St. Paul's almost; and this feeling, again, is another result of the utter uncertainty that prevails about the strength of iron. The matter ends with the architect, when, in a neat bill of quantities endorsed "Smith and Founder," his ironwork goes forth to the builders, and from them no one knows where, certainly, in most cases, all over Great Britain, directly or indirectly; and a contracting builder of the present day will obviously accept the lowest tender, unless something notoriously wrong appears in it. And naturally, therefore, the architect makes himself safe, and allows for a strength of casting which probably the vilest iron in England will give him. Architects often apply tests, but generally only to something higher than their working load, and no valuable knowledge is obtained. In the more conspicuous and ornamental ironwork an architect will examine critically the outside finish and appearance of his castings, quite unaware, in most instances, whether in strength and toughness the iron is 20 per cent. above or below a fair standard. What it is likely to be may be shrewdly guessed from the system under which it may be procured, it having very likely been purchased from the cheapest ironfounder, who cannot use good iron without loss.

In London, where space is valuable, where the skill of the architect is taxed to make the most of the ground, surely it would pay best to use the strongest material, and save in breadth and head-room. Iron is simply iron in the eyes of a builder who does not care to make curious scientific inquiries into the material supplied to him; if it has a good appearance, he is satisfied he has done the best for himself; but it is doubtful if the architect has done the best for his client. In the so-called fireproof structures of the present day, the structures themselves may be so; but when filled with combustible goods, they are destroyed in spite of precaution. A warehouse composed of iron framing, of concrete floors, and stone staircases is looked upon as invulnerable; but when, filled with hemp, and tea, and oil, it catches fire, what of the framework then? Then indeed the iron stanchions and girders are tested. With the intense heat, all their powers change; they bend, they break, they fall, floor crashes through to floor, and the fireproof building is in ruins. Who knows how much turned the scale, and whether just a little more strength and toughness in the iron would not have stood the ordeal? and the building has fallen because of cheap rotten iron, and all the ingenuity that contrived the structure is baffled and defeated. One other small instance, though it may seem a trivial matter—the lamp-posts of London, the most conspicuous and oftentimes repeated objects in the streets, are a disgrace to this city. They are common, clumsy, and ugly to a degree. If elegant, they might give a character and finish to the thoroughfares; but there is no public censor of taste, and a local vestry board asks for the old, old pattern, and, having invited tenders, obtains their pillars, painted and weighed, into store for something like 6l. 6s. a ton. When any one sees a lamp-post smashed by a passing wagon, let him look at the article that was supplied to the parish. Bad iron, and the core perhaps all on one side, will show what is done in open competition and rotten iron.

And if it be now asked what is the remedy for this state of things, it would not be unfair to reply that this should rest with the professional engineer, who needs only to be acquainted with the deficiencies he has to deal with. But, at any rate, some suggestions or hints may be offered for consideration. The main thing to correct is the great uncertainty that prevails, and the more of which is removed, the greater nicety can be given to calculations, and greater reliance placed on them when they are made. At present there is no standard held up for imitation, and every one has his own notions on the matter. If an ironfounder is asked if his metal is "good," it would not be in his human nature to answer but in the affirmative; while if he were asked if his iron would stand a specific strain named in exact figures, he would think twice before he said that which could easily be proved to be false. Again, an honest ironfounder would prefer to have this uncertainty removed. He would know then what was expected from him, and how far he could compete, while at present he may use irons the difference in the value of which may more than cover the margin between the highest and lowest in a row of tenders. And for the engineer how useful would this certainty be! Any experiments he might make, or experience he might gain, would be based on positive facts as to the quality of material, and he would know that in any successive work the same results would follow only where similar construction was combined with the same value of iron. But surely instances and examples are not needed as proofs to support the advocacy of exactness against doubt, and of good against bad.

But of this good against bad let it not be thought that too much is here proposed. The higher qualities of iron have been shown not with the idea that they should be taken as standards and held up for emulation and imitation, but only to prove from

these high proofs how very low by comparison the bad irons are, and that they are much lower than they ought to be. No human being can control or alter the quality of the iron as it is taken from the earth, but it might afterwards be improved to any extent, either by mixing the ores or the metal afterwards. The thing here complained of is, that it is not done to a large enough extent, and that the iron of some districts is used too much in its natural or unimproved state. The worst iron in the country need not be wasted; it has its value, and combined with better sorts would be of good enough quality for many purposes. But the carriage to and fro is expensive and inconvenient, and neither an ironmaster nor a founder can be expected to do voluntarily what is not asked of him by the engineer. Would not the figures quoted here justify a proposition of this kind—that no iron should be considered fit for the market that did not stand 450, and that all bad irons should be brought up to this standard? And, secondly, why should not higher qualities be known and calculated upon as standing at 500 and 550? These are quite within what may be obtained with certainty, and for some purposes would be most useful. Anything beyond this would be exceptional, and for the consideration of engineers in very special cases where it also would be most valuable. In dealing in the precious metals, people look with doubt on 9-carat jewelry, and prefer 15 or 18; but they can at any rate know when they do get the better sort. Why should there not be in iron also a figure or a sign of value—no exact one need be named here? and let engineers generally enforce the value, and avoid the manufacturers who were found to shirk it, and who would not give in practice what a specification demanded. If this could be done, a higher tone altogether would be given to the trade in iron, and engineering works could be conducted with greater precision.

Hitherto the subject of cast iron only has been here discussed, partly because there is not so much uncertainty in wrought iron and partly because in it good material is thoroughly appreciated. But there are a few things here, too, that would be the better for a little ventilation. Here the Board of Trade specifies that not more than 5 tons per square inch shall be applied in tension; but this, of course, leaves to the engineer's option whether the iron shall be equal to 17 tons or 24. In many cases no real tests are applied, and, as in cast iron, the tests that are made are most fallacious. An engineer, in designing a roof, calculates for his tension-rods iron of 22 tons to the inch; and, when his roof is finished, loads it for a test to twice the working weight, while, if he more often broke some iron, he would be better informed. Another good result would follow from this practice. If an engineer demanded from the maker a little piece of every size of T, L, bar, and plate, and broke them, he would not only know their strain, but would also find out which shape of iron stood best with certain strains, and would, perhaps, avoid some sections for the future. Many persons, who are not directly interested in these matters, would hardly credit that such bad iron as is sometimes sold was ever made at all. Lying here is a piece of plate, detected by accident, after having been made into a girder. A chance blow from a hammer chipped it off like a bit of crockery, and its appearance sufficiently indicates its value. Here also is a small piece of iron, 1½ in. × ½ in., which was intended for bonding brickwork together. It looks worse even than cast iron for tension, is as brittle as glass, and would break abruptly without stretching. This also was detected by accident, and reveals what is a very serious fact, that there is a market at all for such stuff. And let it be noted that iron as bad as this cannot be the result of chance misfortune, for it could not possibly have survived the working that in its manufacture it should have undergone. And this working that iron goes through is a safeguard very often. Small rods, T and L iron, must of necessity have a certain value, or they could not have been made at all, and it will often be found that the cheap ironmakers do not care for these sections. Are not the commercial terms applied to iron significant of the demoralisation which has resulted from the absence of fixed standards of value? So unmeaning are these terms, that the worst iron that is made is called "Best." To get a good quality it is necessary to specify "Best, best;" and really superior iron has to be named, "Best, best, best," to give it proper value in the estimation of purchasers.

There are at the present time in the English market many kinds of foreign iron, and especially rolled joists. Some of these are excellent, but some are very inferior, as may be guessed from the price at which it is sold. Built into brickwork as quiet girders, these may serve their purpose, but if an engineer, taking a fancy to the section, should use one for other purposes, let him beware how he twists and turns it, for some of it is remarkably deficient in the fire and on the anvil. As a pleasant contrast may be shown some good specimens, and among them the head of a link made by Howard and Ravenhill's patent process, and which has been washed with dilute acid so as to eat through the skin and reveal the fibre of the iron. It will be seen that, instead of the shear in the hole being across the grain, the iron follows the curve of the head in a very curious manner. These links are rolled entirely from solid blooms of scrap iron, and will stand a strain of about 24 tons and upwards per square inch of sectional area. (The sample shown to-night broke only at 25½ tons.) It is, however, the great elasticity more than the ultimate endurance that gives these links their value. When they are tried in tension up to 12 tons, they will, on being released from the load, return to their former length, and it is only beyond this strain that the permanent set commences. When tried to a breaking point, so great is the toughness of the iron that the links stretch from 1 in. to 1½ in. per foot.

Some other samples of wrought iron are shown here which will be recognised as of a very high kind. As in cast iron, the manufacture is a pure matter of money as to the quality obtained, and is still less than in cast iron a matter of locality. Even the Lowmoor and Bowling irons, of which so much is thought, are to be attributed to careful and systematic working more than to any original superiority of the raw material.

The statements put forward in this paper are given with due deference to the greater experience of older engineers, and the object was more to place prominently in view a certain state of things as at present existing than to give advice as to a remedy. Mr. Kirkaldy has shown what can be done in the analysis of iron; it only remains for engineers to take advantage of his ex-

perience and example. Nothing has been said here of the morality involved in the manufacture of good or bad iron, but when it is remembered how often human lives depend on the structures designed for public uses, and when engineers recall the failures that have occurred within their own experience from defective material, it will be acknowledged that the subject is one of the gravest importance.

With the exception of Mr. Kirkaldy's tests, which were made a few weeks ago, this paper was all written for the last session of this Society, and during the intervening months there have been independent confirmations of the opinion now given. Two engineers of eminence have asked for high strains in cast iron—about 550—one for a public work in London, and one for India, and they will doubtless obtain them.

APPARATUS AND PROCESSES USED IN THE MANUFACTURE OF FURNITURE.*

PARIS EXHIBITION.—CLASS 58.

By LIEUT. OSBERT CHADWICK, R.E.

THE machinery and processes of this class present no great novelties in principle, the chief improvements being in detail and arrangement.

In the English section nothing is exhibited; but as there are in class 54 some machines applicable to the processes to be here described, they will be mentioned, so as to afford comparison with those performing similar operations, which, in the French section, are placed in class 58.

For the same reason some German machines are also included. The following objects are those which will probably be of greatest interest. They are arranged in the order in which they are given in the French general catalogue, as being that by which they are most easily found:

FRANCE.

Perin: Endless ribbon-saws, and specimen of work done by them.

Gérard: A planing-machine; also circular and reciprocating saws.

Arby: Planing-machine.

Barrère and Caussande: Engraving-machine and copying-lathe.

Contamin: Copying-lathe.

In the Park.—Cart: Portable saw-frame for rough timber, with endless band-saws.

HESSE.

Schmaltz Brothers (54): Machine for shaping pieces for parquet floors.

AMERICA.

Whitney's gauge lathe for legs of chairs, &c.

Whinslow: Double serpentine moulding-machine.

ENGLAND.

Worssam: Radial boring-machine; general joiner.

Robinson: Moulding-machine; self-acting cross-cut saw-bench; tenoning-machine.

Powis, James, and Co.: Moulding-machine; boring and mortising machine; combined endless and reciprocating sawing-machine.

Sawing-machines.—Perin, who was the introducer, if not the inventor, of the endless band-saw, shows a fine saw of this kind for cabinet-makers' use. Also, a combined reciprocating and band-saw machine for inlaying. The endless saw runs over three small pulleys, one of which is provided with an arrangement for tightening the saw. The reciprocating-saw works in slides above and below the table, and is stretched by a spiral spring attached to the upper slide by a leather strap. A small boring-spindle is placed at one side of the table, at the front of which is a vice for holding the saw while being sharpened, during which operation the band-saws are placed over two pulleys provided for the purpose.

M. Perin also shows a fine specimen of the work that can be executed by these saws. Powis, James, and Co. also show a similar machine, but of larger dimensions. In this machine the wood packing round the saw beneath the work is independent of the table, which can therefore be inclined, if required, without loss of time from having to fit new packing.

M. Cart has a portable saw-frame for sawing rough timber, with two endless band-saws.

Gérard shows a small circular-saw driven by the foot, which is adapted for all kinds of light work. The table is provided with a slide, with gauges for mitre-joints. For rebating, the whole table can be inclined, so that the saw protrudes to any required extent; for bevelling, half the table turns down on a hinge in the prolongation of the saw, and can be fixed at any angle. A sweep-cutting saw is shown by the same exhibitor, the framing of which is entirely of wood. The saw works between arch-heads, and is tightened by a simple lever, which strains the flat chain connecting the opposite ends of the levers which carry the saw. A self-acting crosscut-saw by Robinson has an arrangement by which the circular-saw moves backwards and forwards in a slit in the table, advancing slowly and returning quickly after making the cut.

Whitney (United States) exhibits a circular-saw table, with a crosscut and a ripping saw, so arranged that either can be brought into play without loss of time. The two saws are supported at each end of a lever carried by an axle in the middle of its length. Thus either saw can be brought up through the opening in the table, and the driving-belt is

taken up by the pulley of the saw that is uppermost. One half the table is made to slide, and is provided with gauges to cut any angle. The other half is fixed, and is provided with a fence.

The circular-saws which are provided with apparatus for boring, mortising, &c., will be mentioned afterwards.

Planing and Moulding Machine.—In the planing-machine of Arby the cutters are in the form of a screw; there are three, and each makes rather more than one-third of a turn. To ensure the cutters being sharpened to proper form so as to cut a flat surface, a self-acting grindstone is attached to the machine. The stone is carried by a frame which traverses across the machine parallel to the axis of the cutter-block, which is for this purpose disconnected from the driving-pulley. On the lower part of this traversing frame, immediately under the grindstone, is a rest against which the face of the cutting-blade is pressed by a weight attached to a pulley on the spindle. The grindstone is moved backwards and forwards across the machine by a screw, while the cutter, from its form, is caused to revolve by the pressure of the rest. In this manner a true helical form is given to the edge. The work is clamped to the table, which moves at the rate of about 12 ft. per minute under the cutter. For planing thin boards the table may be fixed, and the feed is then given by a roller.

Gérard: This planing-machine consists of a vertical disc, pierced with two radial slits, through which the edges of the cutters protrude; they are straight, and exactly similar to an ordinary plane-iron. The work is carried by a table in front of the disc, which revolves at a comparatively slow rate.

The moulding-machine shown by Robinson (class 54) has four cutter-spindles, so that the four sides of the work can be finished at one operation. The upper cutter-spindle can be set slanting, so that, for a moulding much deeper at one side, the cutter need not have such a great difference in size between the two ends. The feed-rollers are driven by an endless screw, and, to adjust them for differences in thickness of the work, their axles move in a circular arc, whose centre coincides with the centre of the driving-wheel, so that they are always in gear. In a similar machine by Powis, James, and Co., the cutter-spindles for the edges of the board can be inclined at any angle, so as to enable them to tongue and groove the edges of boards for cylindrical work, such as cylinder lagging. In this machine the rate of the feed can be changed even while working. The feed-rollers are worked by a friction-pulley which presses against the face of a revolving disc. This friction-pulley can be moved along its axle from the centre of the disc to the circumference, or can be removed altogether from contact, so that the rate of feed can be changed to any required extent.

In Whitney's cylinder plane the horizontal cutter-spindle is fixed, and the table is raised or lowered to accommodate different thicknesses of plank by a simple arrangement. On the under side of the table is an inclined plane, which rests on a wedge. This wedge is moved in or out by means of a screw; and, as the table cannot move horizontally, it is raised or lowered. One turn of the screw raises the table one-eighth of an inch.

Whinslow's double serpentine moulding-machine is designed to mould pieces of an irregular curved shape, such as the backs of chairs or sofas. The cutter-spindle is horizontal, and beneath it, and supporting the work, is a fluted roller. The flutes of this roller are slightly oblique, so as to press the work against a stop projecting from the frame. This pressure causes the work in passing under the cutter to follow any outline to which it may originally have been cut. It is pressed down into the fluted roller by two rollers, one on either side of the cutter. The cutter is made up of small irons, each of which is held in undercut grooves in the edges of two rings placed on the spindle, and tightened by a nut. By this means several mouldings can be made with the same irons by changing their relative positions, and the whole is better balanced.

Schmaltz Brothers, Hesse (class 54), exhibit a machine for parquet flooring which may, perhaps, be classed under this head. Its object is to shape, tongue, and groove the edges of the geometrical figures for this kind of floor. The tool is carried by a vertical spindle, and the work is fixed to a circular tackle, supported by a slide-rest. This table also turns on a vertical axis, and can be turned round through 30°, 45°, 60°, or 90°, and then fixed by a stop, which enters into notches in its circumference. By this means accurate hexagons, octagons, &c., are cut and the edges grooved.

Vanloo, France (5). This machine produces ribbed, beaded, and basket-work patterns of various sorts. A table carrying the wood to be carved moves backwards and forwards under a frame carrying the tool; on each side of this table is a rack, the projections of which act on a sort of cam fixed to the lower side of the frame carrying the tool, causing it to pass over the work with a jumping movement. The form of the cam and the shape to which the edge of the cutter is ground determine the pattern. For some patterns a horizontal movement of the cutter is also required. For this purpose a rack is fixed on the side of the table, and acts on a cam on the frame, as before. The tool cuts both ways, and the motion of the table is self-acting.

The universal moulding, shaping, and recessing machine of Worssam and Co., England (class 54), is one which may be taken as intermediate between the moulding and the boring machines. The vertical cutter-spindle is carried by

a frame which overhangs considerably, so that the work can pass under the tool; and thus it is enabled to work in the centre of a board. For sinking recesses to pattern, a table, carrying the work and pattern, is added, which can be moved by hand in any direction on two slides at right angles to one another. This machine has also a second cutter-spindle, which works below the table, and is brought up by a hand-lever. This cutter revolves in an opposite direction to the top one.

Mortising and Boring Machines.—Of these machines two kinds are exhibited, one with a revolving cutter, and the other with an ordinary mortise-chisel with a reciprocating motion. Of the first kind a machine is exhibited by Gérard. The spindle is horizontal, and can be raised or lowered according to the position of the mortise to be cut. The work is traversed, and the spindle brought up, by racks and pinions. To prevent the lever-handles being sometimes in an inconvenient position, these pinions are loose on their shafts, and can be slid out of gear with the rack and brought to a more convenient position. In the similar machine of Perin there is a second spindle, parallel to the first, which does not revolve, but carries a double-edged fork-shaped cutter for finishing the ends of the mortise, which are left round by the revolving cutter. Similar machines are exhibited by Schmaltz and Geschwind, and Zimmermann. Of the machines with the reciprocating chisel one is shown by Rogers, United States. The chisel is moved by a crank and connecting-rod; and, with crank-shaft and driving-pulley, is brought down to the work by the pressure of the foot applied to a treadle, and raised from it by a weight. When the chisel is allowed to rise to the top of its slide, it is turned half round by a stud, which strikes a spiral cam, so as to cut the other end of the mortise; a similar cam turns the chisel back again when brought to the bottom of the slide.

Tenoning-machines.—Rogers's tenoning-machine, United States, has two horizontal cutter-spindles, with open cylindrical cutter-heads, which are provided with a small saw-spur to cut the shoulder of the tenon. The table carrying the work is raised or lowered by four wedges. The cutter-spindles have independent horizontal adjustments, so that a tenon of unequal depth on the two sides can be cut if required. A similar independent adjustment is seen in Robinson's machine.

Machines performing several Operations.—Worssam's "general joiner" does sawing, planing, and thickening; mortising, tenoning, cross-cutting, and squaring up; tonguing, rabbeting, grooving, moulding, and beading; chamfering, wedge-cutting, and boring. The saw fence can be inclined at any angle, and the table rises and falls, so that any depth of cut may be taken. For planing, a planing disc replaces the saw. Tenons are cut with a double saw, the work being fixed in a clamp which slides along the fence. For grooving, a "drunken saw," or one set obliquely on its spindle, is used. For mortising, boring, or moulding, the tool is fixed on the opposite end of the spindle to the saw, and the work is carried by a sliding-plate, working upon a table with an independent rising and falling motion, so that boring can be carried on at the same time as sawing.

A similar machine is shown by C. Powis. Robinson's circular saw-bench for tonguing, grooving, boring, cross-cutting, and sawing, is somewhat simpler. The saw-spindle rises and falls instead of the table. For grooving, a cutter is employed, replacing the saw. For boring, the auger is attached to the end of the spindle, and the work is carried by a separate table. It is considered better, when expense is not considered, to have a separate machine for mortising, as the motion of the wood in this operation produces a lateral strain on the spindle, which is apt to derange it for planing or sawing.

Various Machines.

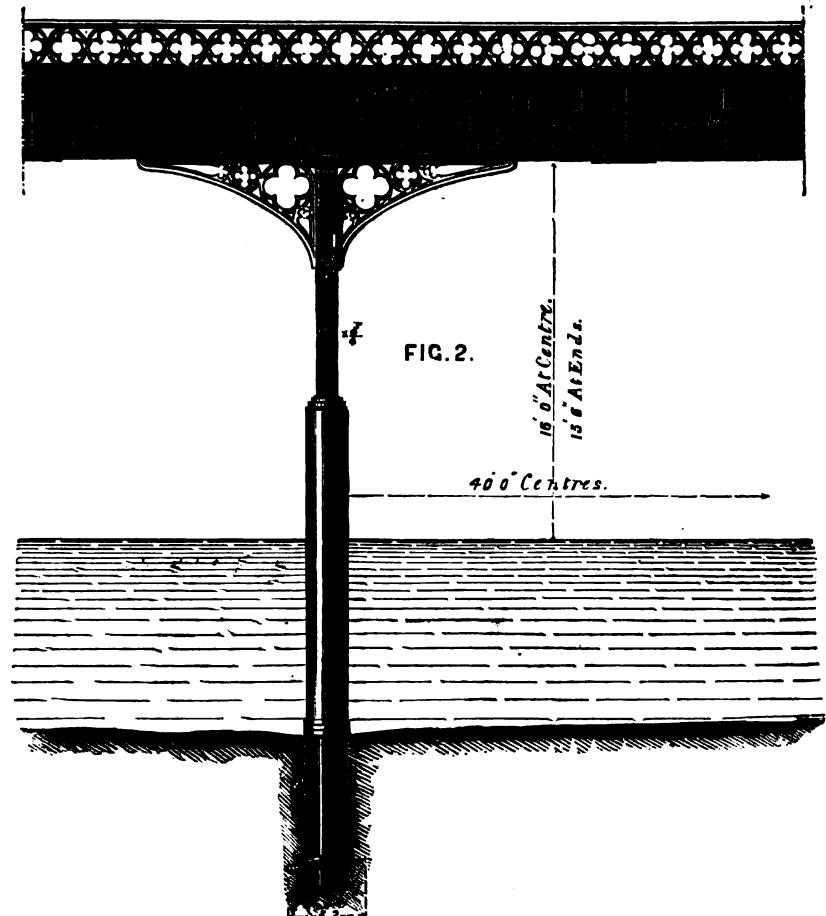
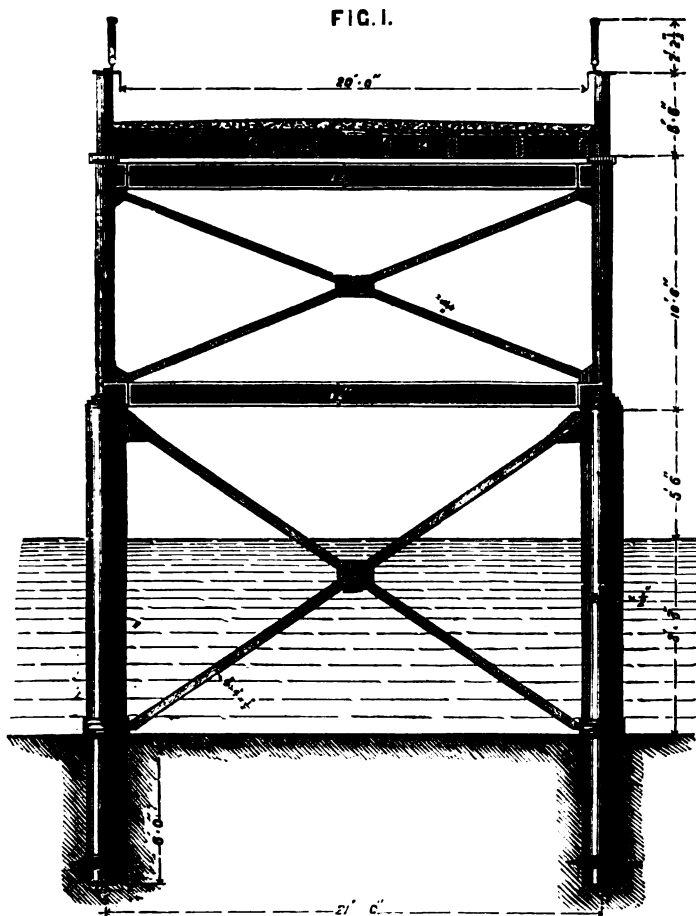
Barrère et Caussande exhibit a machine for engraving. This machine is chiefly intended to produce and engrave the complex patterns which are used in bank-notes. It engraves circles, ellipses, circular and elliptical rosettes. There is also an apparatus for producing small stars at regular intervals, forming thus the ground for bank-notes. It also engraves automatically from the originals or casts, by the "anaglyphographic" process, medals, &c.

A copying-lathe for medals is also shown by the same exhibitors. In this machine the work and the original revolve slowly, at the same speed. A tracing-point moves slowly from the circumference of the model, so as to describe a spiral track over the surface to be copied, and rises or falls as meets the elevations or depressions. The vertical motion of this point is communicated to a drill, which moves in a similar manner over the work. Reduction or enlargement is produced by causing the horizontal movement of the drill to be slower or faster than that of the tracing-point, by means of change-wheels. Contaurin has a similar machine, but the movements are produced entirely by levers.

Whitney's gauge-lathe finishes at one operation the legs and rounds of chairs, &c. It is a lathe with a slide-rest traversed by a screw. This rest carries two tools; one, a chisel, is fixed and roughs off the work. The second, a V-shaped cutter, cuts out the pattern, and is guided by a template fixed to the bed of the lathe. A knife, whose edge is moulded to the form to be produced, moves vertically in a frame behind the lathe; as the slide-rest passes along, this knife descends and smooths off the pattern produced by the first two cutters. In this manner chair legs are produced from a rough square log with an accuracy equal to that attained by hand, and with immense rapidity.

* Jurors' report, reprinted from the *Illustrated News*. See page 343 of the present volume of *ENGINEERING*.

BRIDGE OVER THE RIVER THAMES, AT COOKHAM. DESIGNED AND CONSTRUCTED BY MESSRS. PEASE, HUTCHINSON, AND CO., ENGINEERS, DARLINGTON.



THE bridge over the Thames, at Cookham, of which we publish a perspective view on page 414, and details on the present page, is remarkable, not for its size, nor for difficulties attending its erection, but for the cheapness with which it was constructed. When the Cookham Bridge Company decided on the construction of the new bridge, the directors advertised for designs, and in return thirty-seven plans and estimates were sent in, these estimates varying from 1900*l.* to 27,000*l.*

The tender accepted was that of Messrs. Pease, Hutchinson and Co., of the Skerne Ironworks, Darlington, and 32, Coleman-street, London, whose estimate was 2520*l.*; and premiums were awarded for the two next best designs, those of Messrs. Peto and Co. and Mr. John Pinchbeck, of London.

The length of the new bridge over all is 335 ft., and its length between abutments 300 ft. The clear width of the roadway is 20 ft., and the height of the bridge at the centre, from the bed of the river to the top of the handrail, is 30 ft. The bridge has a rise towards the centre of 2 ft. 6 in. The superstructure consists of a wrought-iron continuous girder supported at intervals of 40 ft. upon piers formed of iron piles. The main girders are 8 ft. 6 in. deep, with webs $\frac{1}{4}$ in. thick, and top and bottom flanges 12 in. by $\frac{1}{4}$ in. The flanges of each girder are joined to the web by pairs of 3 in. by 3 in. by $\frac{1}{4}$ in. angle iron. The girders are firmly bolted to the three centre piers, and ride on the remainder on expansion rollers. They also rest on expansion rollers at the two abutments. Ornamental cast-iron brackets are introduced at the angles formed by the piers and girders, as shown in Fig. 2.

The transverse girders, which are placed 6 ft. 8 in. apart from centre to centre, are of wrought iron, 14 in. deep, with $\frac{1}{2}$ in. webs, and top and bottom flanges each formed of a pair of 3 in. by 3 in. angle irons. The platform is of Memel planking, 3 in. thick, carried by short longitudinal beams, 11 in. deep by $\frac{1}{2}$ in. thick, the ends of which are inserted between the flanges of the transverse girders. The platform was covered with a thick coating of asphalt before the metalling was put on.

The abutments are of red brick, with ashlar caps and string courses. Their face walls are 3 ft., and the wing walls 2 ft., thick at the top, with a batter of 1 in 8. The piers are each composed of two screw piles, as shown in Figs. 1 and 2 on the present page. In order to guard against the action of ice, &c., the lower portion of each pile, up to about 5 ft. above the water-level, is made of wrought-iron plate $\frac{1}{2}$ in. thick. This lower portion of each pile is 1 ft. 8 in. in diameter outside, and it is filled in with concrete. The upper portion of each pile, which is of cast iron, is 10 in. in diameter and $\frac{1}{2}$ in. thick. The transverse girders connecting the piles are 12 in. deep, and the cross bracing of the lower portions of the piles consists of 4 in. by 4 in. by $\frac{1}{4}$ in. angle irons and that of the upper portions of flat bars 4 in. by $\frac{1}{2}$ in. The piles are screwed down into the bed of the river to depths of from 6 ft. to 10 ft.

The contract price for the bridge was, as we have already

stated, 2520*l.*, a remarkably low one for the work done, and only explicable from the fact of the contractors being large iron manufacturers as well as extensive bridge-builders. There were no extras charged, and the amount above mentioned included the iron, brick, stone, and timber work, the excavation, labour, erection, carriage, &c.; in fact, the cost of the whole bridge, complete as it now stands, in addition to the removal of the old structure, which it replaced.

We are indebted for the particulars of the Cookham Bridge to Mr. W. G. Fossick, under whose superintendence the work was quickly and successfully carried out. The bridge was erected under the inspection of Mr. William Atkinson, C.E., of Westminster, who acted as the representative of the Cookham Bridge Company.

THE MISSISSIPPI BRIDGE AT ST. LOUIS.

A few weeks ago (*vide* page 306 of the present volume) we published an account of the proceedings of the committee of engineers appointed to determine upon the best method of constructing the foundations of the bridge to be erected across the Mississippi, at St. Louis, and we now lay before our readers the report made by that committee, as well as the reports of the other committees appointed to investigate the character of the river bed, and to decide upon the best form of superstructure to be adopted:

REPORT OF COMMITTEE ON THE REGIMEN OF THE RIVER AND THE CHARACTER OF ITS BOTTOM.

St. Louis, August 24, 1867.

Wm. J. McAlpine, Esq., President, Board of Engineers.

Dear Sir,—The committee on the regimen of the river and the character of its bottom have had the subject matter referred to them under consideration, and submit the following report in relation thereto. The questions submitted to the committee are such as would require long and patient investigation and great labour to answer them fully; but believing that a brief statement of facts and conclusions will answer all the purposes of the board on the present occasion, your committee has concluded to present the results of their observations, leaving out the modes through which they were attained.

The Mississippi river, at St. Louis, at extreme low water, has a minimum width of 1520 ft., and about 2000 ft. at extreme high water; these widths are in excess of what is required, and it would be safe to contract the low-water channel to 1200 ft., and the high-water channel to 1800 ft. Calling the city directrix (which is high water, as generally understood) zero, then low water is minus 38.81, and the extreme high water of 1844 was plus 7.58 ft., making a total rise and fall of 41.39 ft. The flood of 1851 was plus 2.80 ft., and that of 1858 was plus 3.20 ft. With these exceptions the high water has never exceeded zero. The period of flood varies from April to July, though the great floods usually occur in the latter part of June, and are caused by the melting of the northern snows, meeting the late spring rains on the lower tributaries. The coincidence of these condi-

tions in the Mississippi and Missouri rivers caused the great floods above mentioned, especially that of 1844. At the periods of flood, the surface of the river is covered with immense rafts of drift wood, composed of large trees, logs, lumber and other similar materials, frequently matted together, and generally occupying the main channel of the river, but often driven out of it by strong winds blowing transversely to it.

The maximum velocity of the current in the main channel, at a depth of 8 ft. below the surface, varies from 4 ft. per second at a stage of water minus 38.81 ft., to 12 $\frac{1}{2}$ ft. per second at a stage plus 7.58 ft. The average descent of the river surface is about 6 in. per mile.

In surveys covering a space of thirty miles, from the mouth of the Missouri river, twenty miles above, to Jefferson Barracks, ten miles below this city, the width of the river, at extreme low water, is found to vary from 2500 ft. to 900 ft.; and where it is more than about 1200 ft. wide, a bar exists, either in the middle or at one of the shores; and in places where the greatest width obtains, the channel is usually divided by bars in several parts. At St. Louis the bar is in the central part of the channel, a little to the east of the middle. This bar varies much in extent, in different years, depending upon the source of the flood, its duration, and the manner of its abatement. Thus, if the flood is from the Missouri river, and no flood in the Mississippi river, and the flood is of long duration, and abates with a rapid decline, the bar, under these circumstances, attains its greatest development. If the flood is from the Mississippi river, and no flood in the Missouri river, and there occurs a long period when the river is of medium stage and the decline is gradual, then the bar attains its minimum development, as it becomes absorbed by the clear water of the Mississippi river; but it is always there, to some extent, and will so remain until the low-water channel of the river is narrowed down to about 1200 ft. Some seasons it is 5 ft. above the low-water surface at Biddle-street, and 2 $\frac{1}{2}$ ft. below the same at Market-street. Under these circumstances circuitous routes have to be pursued in crossing the river at the ferries, and under more favourable circumstances no ill effects are observed. In some seasons the ice grounds upon this bar, and it assists in producing an ice gorge in the harbour. The largest accumulation of ice is when the river is at a stage between minus 24 and extreme low water; there is seldom much ice at a higher stage. The usual run of ice is in broken and detached masses, which at times cover the entire surface of the river, and finally press so closely together, that at narrow points in the river they cement together, forming a gorge, and the detached floating ice, coming down, lodges against the gorge, and gradually extends it up stream for many miles, leaving an open river below. Much of the floating ice coming from above doubles under the gorge, and often renders it solid from the surface to the bottom, and has caused the river to rise as much as 8 ft. in a few hours. This gorged ice has been observed as thick as 10 or 12 ft.; the size of the masses of floating ice, under ordinary circumstances, is often as large as 50 ft. by 150 ft., and 1 ft. thick; but immediately at the point where the river breaks up, the masses of ice often move off in fields as large as 500 ft. by 1000 ft. in area, and 12 in. to 14 in.

thick. The movement usually commences very slow, and increases as the masses become smaller. The velocity of floating ice is less than 3 ft. per second when the river is very full of it, and, when not full, the velocity becomes nearly the same as the current upon which it floats. A heavy run of ice deadens the current, and consequently causes the river to rise in due proportion. The river is closed on an average about once in three years, and remains closed from two and a half days to two and a half months. It has been known to close early in December and remain closed until the latter part of February. It usually closes in December, which is the period of extreme low water. The river generally closes by gorging, but it has been known to freeze directly over in one night. After freezing over the river usually rises permanently from 6 ft. to 8 ft., even after the immediate effects of gorging have ceased. If the gorge be very completely packed, the rapid rise in the river will often break it away, and the whole ice-floe will then pass off. Continuous cold weather, ranging as low as zero, and a low stage of the water must be coincident in order to close the river, and even then it may not close here if a gorge has taken place a few miles above. A compact gorge, formed in this latitude in the early part of the season, will cause the river below to remain open and navigable throughout the winter, as the ice does not form usually with sufficient rapidity south of this latitude to cause a second gorge; and thus obstructions placed in the river at this point, so as to produce a gorge, would render this place continuously open to navigation from below.

The character of the deposit left in the bed of the river by floods varies from a coarse silicious sand to a slime consisting of calcareous and aluminous matter with vegetable mould; the former is deposited in and near the channel, and the latter on the low grounds and in abandoned channels from the strong currents of the river, so that quicksand is not likely to be found in the immediate bed of the river, nor adjacent to it, at a lower level than low water. Clay deposits are sometimes formed, which are doubtless the result of special causes, and perhaps they are generally formed by deposits from the Upper Mississippi river. The shifting material at the bottom of the river changes 10 ft. or 12 ft. in the course of several seasons; a continuous change is going on, and each year it is various, depending upon the character of the floods, whence they originate their magnitude and duration; changes of 30 ft. in depth have occurred in a few years where abandoned channels silted up. It is a matter of speculation as to what depth below water the current may exercise a scouring influence, but in a distance of 20 miles, partly above and partly below this city, a thorough sounding of the river was made during the low-water period of 1860-61, and no greater depth was found than 30 ft. (the sounding being reduced to low-water level); under peculiar circumstances, such as a bridge pier might present, the scouring influence might extend to 40 ft. in depth. It has been alleged that in the winter of 1855 a depth of 80 ft. was found in the river opposite to the foot of Bates-street; but no credence can be given to the report, as the sounding made by R. E. Lee, U.S.A., in 1838, those of Clement Coote in 1843 (then city engineer), those of the city engineer in 1861, and those made by H. Kayser at various periods, all contradict this statement. Indeed, the greatest depth recorded by any one of the observers mentioned does not exceed 40 ft., and it is uncertain what was the stage of water when the greatest recorded depth was found. The circumstances under which this great depth existed were similar to those which would be produced by placing a bridge pier in the channel of the river in such a position that the main force of the current would break against it.

Four borings were made in the river in continuation of the north line of Green-street; the first at a distance of 265 ft. east of the west line of the wharf, where the rock was found coincident with the bed of the river at minus 56.70, or 22.89 ft. below low water; the second at a point 500 ft. east of the last point, where the rock was found at a depth of minus 97.46, or 63.65 ft. below low water, and the water had a depth of 13.7 ft., leaving 49.95 as the thickness of the river deposit above the rock; the third was at a point 500 ft. still further east of the last point, where the rock was found at a depth of minus 123.33, or 89.52 ft. below low water; here the water was 10.19 ft. deep, leaving 79.33 ft. as the thickness of the river deposit above the rock; the fourth was at a point 500 ft. still further east, where the boring was carried to a depth of minus 101.42, or 67.61 ft. below low water, and then abandoned on account of the breaking up of the ice. At this point the water was 16.19 ft. deep, and the river deposit was penetrated through a thickness of 51.42 ft. These borings were made early in the winter of 1866-7. As far as observed, the material was coarse sand with scattering pebbles, and at times a clayey discoloration of the water pumped out of the pipes for the first 20 ft. in depth; below that depth an inch steel-shod rod was driven, which appeared to pass through compact materials of apparently uniform density. It would be idle to speculate upon the precise character of this material, but it may be safely inferred that it is sufficiently consistent to uphold and sustain piles loaded with superincumbent weights, especially if well protected from the scouring influences by stone rip-rap. It may be here remarked that stone rip-rap is the best, cheapest, and most simple method of protecting constructions based in the bed of the Mississippi river, or within the influence of its currents.

As an evidence that the bed rock, over which the river flows, is covered with hard materials, it may be stated that a series of borings were made in four sections, across the Missouri river, at the city of St. Charles, in the winter of 1866-7, the distance being 45 miles from St. Louis by river; they were made for the purpose of determining the foundations for a bridge over the Missouri river, on the line of the North Missouri Railroad, and all in the space of $\frac{1}{4}$ of a mile, at distances transversely of 100 ft. apart along each section. The boring was done with an inch iron boring-rod, pointed with steel, and driven with a light shackle-ram. The "overlay" found was common river sand, often moved by freshets (but not to so low a depth, it is presumed, as, at this period, to reach the hard stratum), was found to be on an average 3 ft. thick, presenting a surface that sometimes broke the steel points and bent the boring-rods; but after piercing this stratum, the rod was easily forced down to the rock. Information, which at that time was regarded as reliable, went to show that a similarly hard stratum was found while boring for the foundations of a bridge over the Mississippi at Quincy,

Illinois. From these coinciding facts it appears highly probable that this hard stratum at one time formed the bed of these rivers 45 miles above on the Missouri, and 160 miles above on the Mississippi. It is difficult to conjecture what it may be composed of, but it is most likely, gravel packed in clay. At St. Charles one unshod oak pile was driven to this hard stratum, but not through it, though it is believed that well-shod piles may be driven through it, and there is no doubt that it would form sufficient lateral support for piling. Certainly no washing or scouring influence can disturb it, especially so if it be protected, even slightly, by a rip-rap of rock. The depth of the rock under the bed of the river is such that it is difficult to conceive how the scouring effects of the currents could ever reach so low, and yet it is manifest that the deep bed of the river has been excavated out of the rock by the action of currents of water; and if the forces which produced this be still active, may the river not again scour to an equal depth? It is not, however, possible that these forces are still active; for when the excavation was made, the level of the Gulf of Mexico extended along an arm of the sea to a great distance inland, some suppose as far as New Madrid, others as far as Baton Rouge; in either case, the water level of the river at St. Louis was much lower than at present, and it is easy to conceive that level to have been from 80 to 100 ft. lower than it is now. If we were once within 500 miles of the Gulf (we are now about 1400 miles distant from it) and 366 ft. above it, there must have been a continuous rise in the water level from the period when the excavating process ceased up to the present time; therefore the tendency of the river has been to cover the bed-work deeper and deeper, as the delta of the Mississippi extended out into the Gulf of Mexico, and the deep scouring of a former period is not possible to occur again. Besides this, there are indubitable evidences that a much larger volume of water once flowed through the Mississippi valley to the Gulf than now finds an outlet in that direction. The upper lakes—Michigan and Superior—once emptied their vast surplus waters into the Illinois river. This, combined with the other causes mentioned, seem to be so potent that it would be wonderful if we did not find evidences of deeper scouring in past periods than are apparent in the present. It is more than probable that remains of timber may be found to a depth of 40 or 50 ft., which will present obstacles in the sinking of foundations, but below that depth it is more than likely that the action of the elements, during the great length of time that has elapsed since their deposition, has destroyed every vestige of their organism, and they no longer exist as obstacles in the path of subaqueous excavations.

There may be a question as to the character of the rock found in the bed of the river, but all the evidences tend to prove that it is stratified limestone. The two artesian wells, sunk to a depth of 2200 ft., and the outcrop along the Mississippi river, and Iron Mountain Railroad south, and the Pacific Railway west, leave no doubt upon this subject. In long distances the average dip to the north-east is less than 1 in 100; so that the excavated bed of the river will present a shelving surface. It is not likely that boulders will be met with, as they are rare bodies in this vicinity. That the rock was reached in the borings mentioned is evidenced by the points of the boring-rods being battered; and subsequent tests, 300 ft. lower down the river, have closely identified the existence of the bed-rock in the same place, the city of St. Louis standing on limestone.

In conclusion, your committee would beg leave to express their keen sense of the inadequacy of this treatment of the great questions confided to them as an important branch of the subject before the assembled Board; but, desiring to extend their remarks no further than is deemed necessary to form a basis of action for the other more important committees, we close with the sincere hope that your clear understanding of the subject will supply all our omissions, and that our brief remarks may thus serve the purposes intended.

Very respectfully, your obedient Servants,
(Signed) TRUMAN J. HOMER,
(Signed) J. B. MOULTON.

REPORT OF THE COMMITTEE ON THE FOUNDATIONS AND PIERS.

The committee, to whom was referred the subject of "Foundations and Piers," have had the same under careful consideration. It has received valuable aid in its labours from other members of the Board, and from the committee on the "Regimen of the River." The local knowledge of the latter, and the former investigation by its members of kindred subjects, at once furnished them with important data in regard to that branch of the investigation.

At a later period, a joint meeting was held with that committee and the Committee on Superstructure, in order to consult and determine upon such points as were common to all, and which would form portions of the basis of their separate conclusions. At this joint meeting all that was deemed necessary as pertaining to the consideration of the subjects which this committee had specially in charge was developed.

The members of the Committee on the Regimen of the River stated the result of their own investigations and that of others, extending over a course of many years, as to the periods and action of the Mississippi river; the character of the material forming the bed and sides of the stream; the disposition and amount of scouring and silting, and the causes, so far as came within their observation. Their opinion as to the extent of the same that would be due to the erection of piers for the proposed bridge; the movement and effect of ice and ice gorges; and the information gained by Mr. Homer during his soundings and borings in the river and its bed, from the mouth of the Missouri river to Jefferson Barracks, and particularly in regard to the certainty that the rock found below the bed of the river, at the depth shown on his cross sections, was rock in place and not boulders, and the extensive deep borings made by Mr. Moulton at St. Charles, which developed the deposit at that place nearly similar to that at St. Louis. The committee finds that the bed of the river down to the rock is composed of coarse silicious sand and aluminous and vegetable matter, with an occasional stratum of compact sand and clay. In times of freshets and their subsidence, when the velocity of the current takes a range from six to eight and one-half miles per hour, bringing with it, principally

from the Missouri river, vast quantities of sand and other matter, that the extent of the change in the level of the river bed amounts to about 12 ft. In no place for miles above and below the city has the amount of scouring been found to exceed a depth of more than 30 ft. below the level of low water, and this depth is regarded as the extreme. The deposits of sand, silt, &c., are usually made when there is a rapid decline of the Missouri floods, and the greatest scouring takes place during a long continuance of a medium Mississippi flood, whose clearer water at a certain velocity takes up and carries with it the turbid deposits brought down by the Missouri.

That part of the river opposite the city, and for a short distance above and below it, is within a range which is peculiarly subject to changes, owing to the various and varying character of the influences of the two great streams above it. These rivers, with their sources hundreds of miles, one to the northward and the other to the westward, among the great mountain ranges extending above the snow line, pass through many degrees of latitude and longitude, each with its own climate; and when the season of spring storms has passed away, and no longer influences the volume of water, a succession of rises in the river follow from causes operating far away in the mountains to the north and westward, whose storms and melting snows send down volumes of water miles in breadth, and of great depth and rapid current. The fall in the lower Missouri is about 10 or 12 in. per mile, and that of the Mississippi 6 in. per mile. The former passes through hundreds of miles over a river bed and between shores composed of light sand and alluvium of too little specific gravity to resist the action of the floods, and is carried down the stream (in suspension) in great quantities, the water making great inroads upon the shores and the material of which it is composed, helping to fill the water with all it can carry, until the changes in velocity, eddies, &c., compel it to precipitate this material in the form of bars, new shore-lines, or filling up old channels. At every rise, therefore, the Missouri is observed bringing great volumes of material in suspension into the Mississippi; and a flood occurring simultaneously with that of the clearer Mississippi, or a low stage in the former and a high stage in the latter, floods acting jointly or separately, equal or varying in volume or velocity, produce a variety of contingencies attended with the most perplexing results, and, without a thorough understanding of the causes named, it would be impossible to form any reliable opinion as to the probable future effect upon that part of the river which it has become the duty of the committee to examine.

At this distance from the mouth of the Missouri river the bars and channels, aided by judiciously placed dykes, have fortunately assumed a somewhat regular character, varying, it is true, with every change in the stage of water, but within limits, that have been carefully observed and noted through a course of years, amply sufficient in extent to enable a correct opinion to be formed as to its future action and habits.

The erection of piers near the channel, and on the bar opposite the city, will be an additional feature in the causes which combine to produce changes in the river bed, and the committee, aware of the grave importance pertaining to this branch of their duties, have given to it a degree of attention equal to that of any other that has been under discussion.

The failure of important structures at other places from this cause alone has been well and carefully considered, and the reasons of such failures duly weighed and commented upon. It has not lost sight of the fact that one of the ablest and most experienced engineers in Europe lost in this way one of the finest structures of the period; and they have endeavoured to give especial attention to the dangers here, and in their recommendations to provide against all possible contingencies which might arise to endanger the safety of the proposed structure at this point.

In view of all the circumstances, therefore, the committee resolved that in all the plans of foundations and piers that would be under discussion, the depth of the scouring away of the river bed alongside of the piers should be regarded as equal in extent to 45 ft. below low water. This depth is regarded, under all the circumstances of the case, as amply providing against all possible future scouring; besides which, means will be taken to reduce this scouring near the piers to its lowest possible limit.

A selection of some or one of the well-trying engineering methods for this purpose, to be determined upon as the work of the construction of the foundation develops, can be made to prevent the action of the currents from materially altering the position of the material which supports the foundations and piers. In all of the plans considered, however, the calculations disregard any other support than that which will be obtained below the line of the utmost possible scour, if the material was left or should hereafter become unprotected from the action of the water.

The requirements of the Federal law in regard to this bridge compel the use of piers and superstructure of great size and weight, and even for the least alternative spans permitted to be used more than the usual amount of supporting power must be provided for in whatever plan of foundations is finally determined upon. The law requires that the superstructure over the main channel shall, at its lowest point, be at least 50 ft. above the city directrix, or high water. The shortest spans permitted over the main channel are two of 350 ft. each in the clear at low water. The weight of superstructure and piers, under these circumstances, is therefore very great, particularly if the latter are to be built of stone. One of the heaviest of the latter was ascertained to be 6000 tons, if built solid, and the former, with the greatest loads it would have to support, 2500 tons, making a total weight bearing on the foundations of 8500 tons. If this weight was placed upon wooden piles, it would require 210 in number, each pile being required to support 40½ tons.

The satisfactory data before the committee, corroborating the results furnished by Mr. Homer, induce it to rely on the fact of rock in place being found at the depth named, and not boulders. The depth at which the rock is found is as follows: At the west shore the rock is 23 ft. below low water, the depth of water being the same; at 500 ft. east of this point the rock is 64 ft. below low water, and the depth of water is 14 ft.; at 500 ft. further east the rock is 90 ft. below low water, and the water is 10 ft. deep; at 500 ft. still further east, the boring was made to