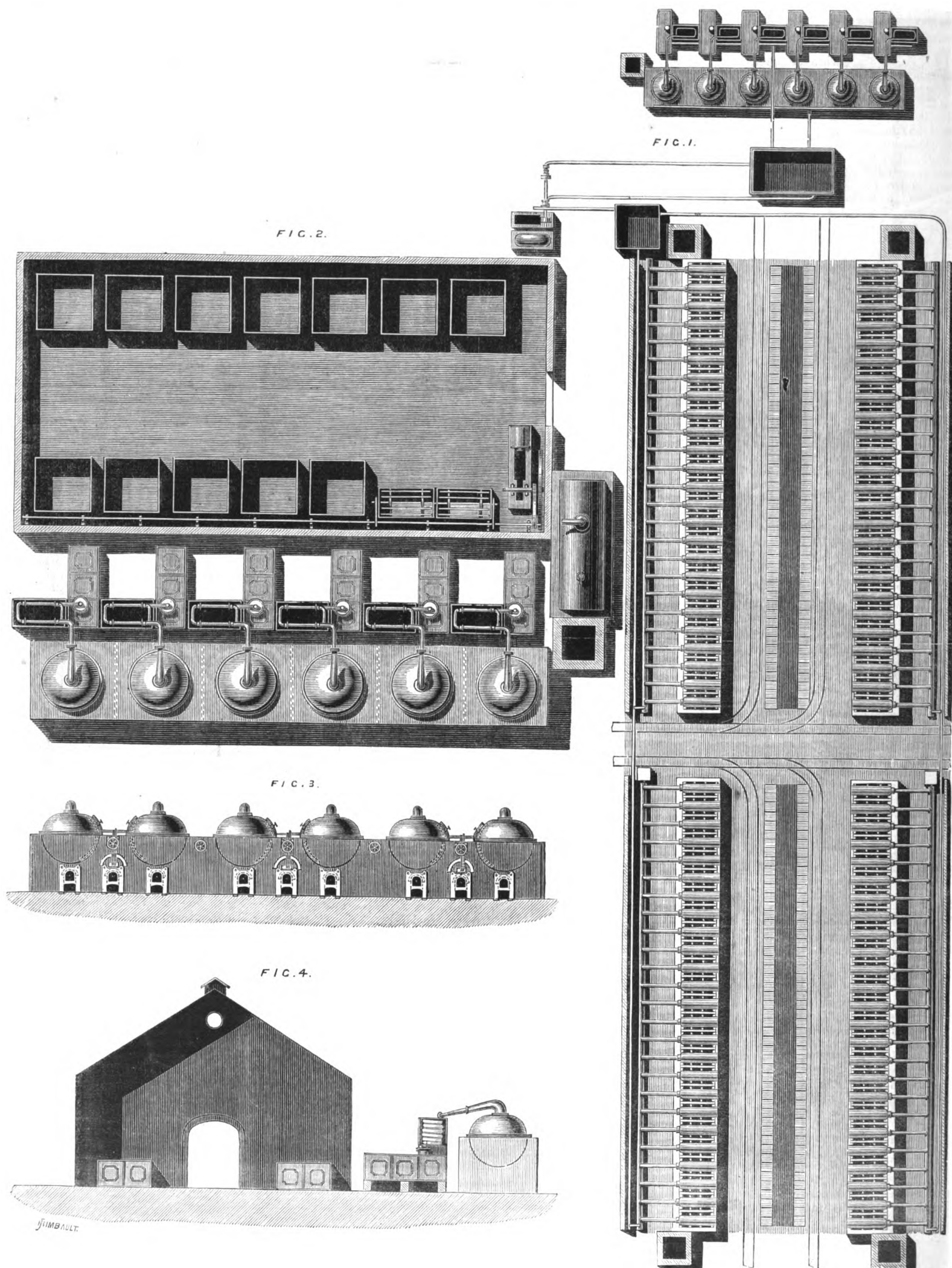


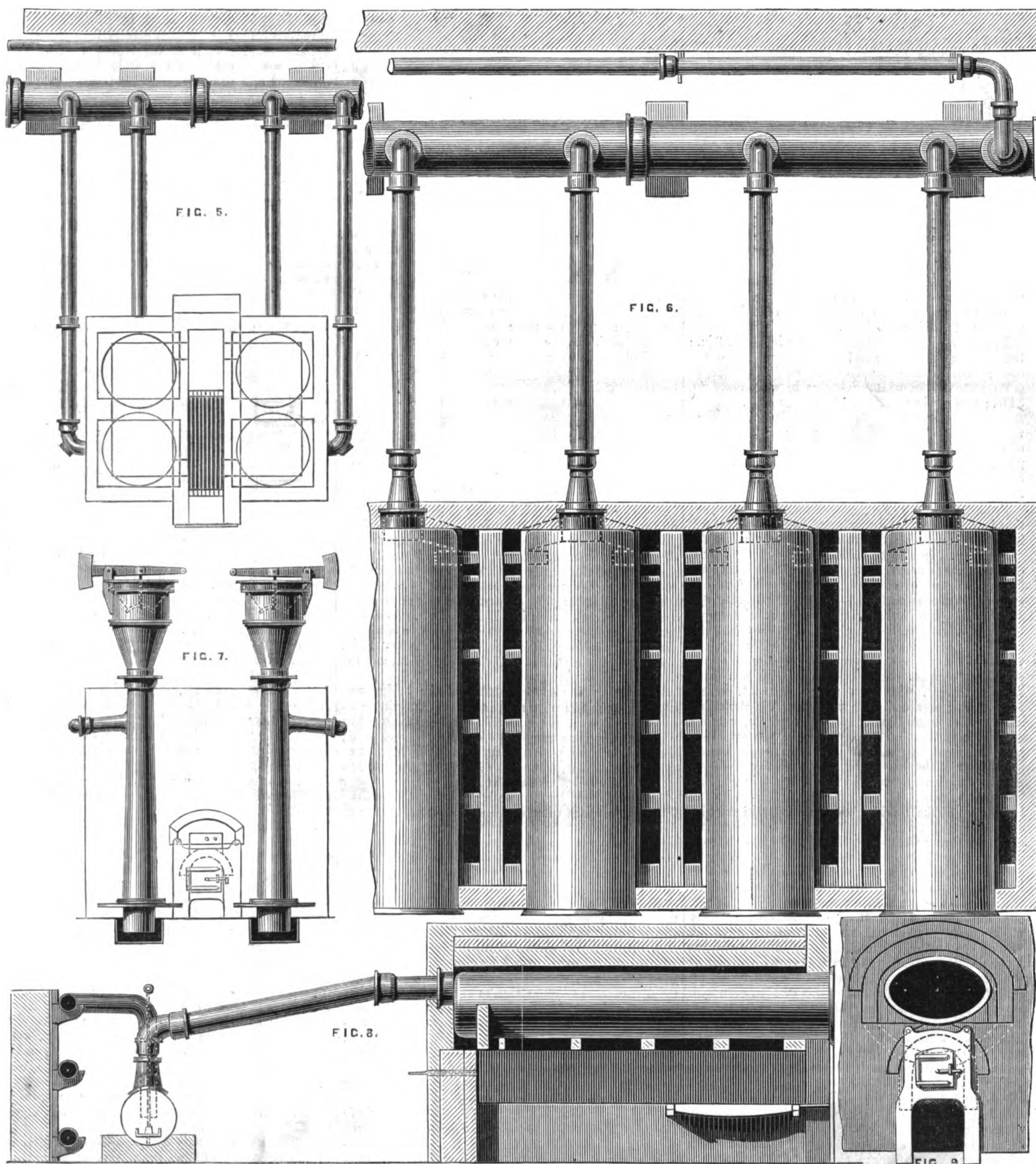
PLANT FOR MINERAL OIL WORKS.

MESSRS. JAMES BENNEY AND CO., ENGINEERS, GLASGOW.

(For Description, see opposite page.)

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On the opposite and present pages we represent the general appearance and some of the principal details of a factory for distilling oil from coal or bituminous shale, such as now in general use in this country. The two principal elements of this plant are the retorts and the stills. The retorts are of two kinds. Figs. 5 and 7 represent the vertical retort, as adopted by Mr. James Young, and largely introduced in different works. The vertical retort is continuous in its action; it is charged through a hopper at the top, which is covered by a counterweighted cone. The joint between the hopper and its lid is kept gas-tight by a small quantity of moist sand thrown upon the top of the cone. The bottom of the vertical retort is open, and stands a few inches deep in water to shut off the gas. The water is held in a cast-iron dish or pot standing some 4 in. or 5 in. clear from the bottom of the shoe of the retort. This gives space for raking out the extracted shale. Figs.

6 and 8 show the arrangement of a set of horizontal retorts. These are closed at all sides, are filled through a charging-door in front, the same as gas retorts, and are opened after the evaporation of all the crude oil for being cleaned and refilled with fresh raw material. The vertical retorts are shown in groups of four, fired from one grate. This is the plan first adopted at the Bathgate Works, but supplanted in more recent constructions by single or double groups of three retorts each. At the Addiewell Works, in the last improved arrangement, six retorts are worked by one fire. The horizontal retorts are shown with a special firegrate and set of flues for each retort, but this is not the only modification of setting and firing retorts of that kind now in practical use. They are frequently set in groups of three or five over one grate, the same as the retorts in gasworks, and are occasionally grouped together for the sake of economy in fuel and space. The stills are represented in Figs. 1, 2, 3, and 4. These are hemispherical cast-

iron stills, such as made in the Kinning Park Foundry; they are set upon brickwork, the covers being secured to them with a gastight joint made of a pasty cement, which is capable of withstanding a very considerable heat. The still covers are fitted with the proper escape pipes, and the cooling apparatus or condenser is arranged in front of each still. The stills are placed in one row, and the tank into which all the cooling pipes pass is generally made without any divisions. Each cooling pipe, however, is entirely independent of its neighbours. The specific heat of paraffin oil is very small, and consequently the supply of cold water to the tank containing the cooling pipes is not very great in quantity. The view showing the arrangement is confined to a crude oil works, there being no provisions shown for the further treatment of the oil in refining. We expect at a future time to give some drawings of the most modern machinery employed in refining paraffin oil and in making the solid paraffin.

CLIFTON SUSPENSION BRIDGE.

It is a rather noteworthy coincidence that during the same month of the current year two eminent engineers—Mr. W. H. Barlow and Mr. J. A. Roebling—hailing from opposite sides of the Atlantic, presented to their professional brethren details of the design and erection, by them, of the longest span bridge in the old and new world respectively. Both bridges are, on the suspension system, but beyond that similarity nothing is in common; the application of the principle and the details of design are entirely different.

Mr. Roebling's magnificent bridge across the Ohio has been fully illustrated and described in our columns; and in a letter signed, "An English Engineer," the design has been freely criticised, and some inconsistencies in the construction, considered with reference to the avowed aim of the engineer, have been pointed out. In giving a brief description of the bridge across the Avon, commenced thirty years ago by Mr. Brunel, and completed last year by Messrs. Hawkshaw and Barlow, we consider it will be instructive to call attention to the different methods pursued by the English and American engineers in working out similar problems.

In the English bridge the clear span is 702 ft. 3 in.; the deflection of the chains 70 ft., or about $\frac{1}{10}$ th of the span; the distance apart of the chains, centre to centre, 20 ft.; the width of bridge between parapets, 31 ft.; and the height above the river, 248 ft. In the American bridge the span is 1000 ft.; deflection of wire cables, 89 ft., or $\frac{1}{11}$ th of the span; distance apart of cables, 20 ft. at centre of span, 50 ft. at summit of piers, and 36 ft. (the width of road) at the anchorages. The height above the water varies from 102 ft. to 104 ft., according to the temperature.

From the above general proportions it will be seen that less proportional disturbance from unequal loading will occur in the 1000 ft. span bridge than in the smaller one. In similar spans, under like conditions of load, the vertical disturbance of the platforms during the passage of a rolling load would be inversely as the ratio of span to depth—in the present instance as 10 : 11.3. The horizontal stability of the larger bridge is, of course, immensely superior to the other, on account of the cables being 50 ft. apart at the top of the piers, whilst they are only 20 ft. apart at the centre of the span. A little consideration will make it evident that, with such an arrangement, lateral movement is resisted by the weight of the structure, since no horizontal displacement could take place without elevating one parapet of the platform to a greater extent than the opposite one would be depressed, and the difference multiplied by half the weight of the bridge would be the work done in resisting lateral movement. On the other hand, this advantage is obtained at the sacrifice of equilibrium in another direction, and we are surprised no attention was called to that point, either in Mr. Roebling's very detailed report or in the discussion at the Institution. As the suspenders from the cables to the platform are inclined outwards at a slope of 1 in 6, to establish equilibrium the weights on opposite rods must be similar; in other words, the load must be practically uniformly distributed over the width of the platform. The effect of this condition in the Ohio bridge is that if the people crossing were to collect on one side of the platform—a very likely contingency—the lateral deflection would amount to upwards of 1 ft., even with the very light moving load of 30 lb. per square foot. If the live load were heavier in proportion to the gross load, this condition would be a very important one: thus, in the Clifton bridge the live load is $\frac{1}{4}$ th of the gross load, whilst in the Ohio bridge it is $\frac{1}{8}$ th; this difference alone would be a sufficient reason why it might be advisable to adopt inclined suspenders in the one case and vertical ones in the other. The small ratio of live to gross load in the American bridge is, of course, another element of stability. Thus, excluding all extraneous stiffening agents, the proportional inherent stiffness of the two structures would be as $2.6 \times 10 = 26$ for the Clifton bridge, and $4.6 \times 11.3 = 52$ for the Ohio bridge, that is, the larger span possesses precisely double that obtained in the other.

The American engineer, however, was not satisfied with this amount of stability, but proceeded to stiffen his bridge in two ways. First of all no less than 76 diagonal cables were carried from the summits of the piers to different points on the stiffening girder, and this girder was made 10 ft. deep, or $\frac{1}{10}$ th of the span, whilst in the English bridge the stiffening girder is only 3 ft. deep, or $\frac{1}{11}$ th of the span, and the diagonals are altogether omitted. There can be no question that

this American bridge is immensely *stiffer* than ours, and we will now compare them as to strength.

Taking first the Clifton bridge, the sectional area of the chains at the centre is 440 square inches, at the piers 481 square inches. The weight of chains between points of support is 554 tons, and the resulting strain at the centre 680 tons. The weight of suspension-rods, longitudinal and cross girders, bracing, and roadway is 440 tons, and the resulting strain 597 tons. The moving load at 70 lb. per super foot amounts to 600 tons, and produces a strain of 817 tons. The total strain at the centre, therefore, amounts to 2094 tons, and the strain per square inch on the links under that strain is 4.76 tons. It may be observed that all the links were tested up to 10 tons per square inch. The suspension-rods are placed 8 ft. apart; the weight on them is 13 tons, and the strain $4\frac{1}{2}$ tons per square inch. The platform is stiffened by a pair of plate girders 3 ft. deep, with flanges 11 square inches area, and by a pair of parapet lattice girders 4 ft. 9 in. deep, with flanges $4\frac{1}{2}$ square inches sectional area. Lateral stiffness is afforded by a system of horizontal bracing, with bars 4 in. $\times$ $\frac{1}{2}$ in.

In the American bridge the section of chains at the anchorage is 380 square inches, and the ultimate resistance, at 25 tons per square inch, is 9500 tons. The strength of the wire cables ($12\frac{1}{2}$ in. diameter) attached to these anchorage chains is 8424 tons. The united strength of the diagonal cables ($2\frac{1}{2}$ in. diameter) is 6840 tons, so the total resistance offered by the ironwork is 15,264 tons. With a live load of 30 lb. per square foot, the distributed load will be 360 tons live and 1300 tons dead; total, 1660 tons. This load will produce a strain of 2598 tons; and as we have seen the ultimate strength is 15,264 tons, the

factor of safety will be $\frac{15264}{2598} = 6.1$, about. The

suspension cables, which are connected with the diagonals at each intersection, are spaced at 5 ft. intervals; the circumference of the wire rope used in that portion is 5 in., and the strength 45 tons. The anchorage chains are gradually reduced in section as they curve over the mass of masonry forming the anchorage, and they are secured to a pair of immense anchorage plates, measuring 17 ft. by 14 ft. The cross girders are strengthened at the centre by a couple of distributing girders, one 9 in. and the other 12 in. deep. The main stiffening girders are 10 ft., and the parapet girders 4 ft. deep.

In each instance the erection of the bridge was effected by means of a small temporary staging suspended by wire ropes. In the Clifton bridge eight wire ropes, of the strength of 35 tons each, were used; six of these were placed below the platform, and two at a height of 3 ft. 6 in. above that level, in order to serve as handrails. An additional rope was suspended at a still higher level to carry two light travelling frames fitted with wheels and other arrangements to enable the links to be handed to the men engaged in erecting the chains. The erection of the chains was commenced simultaneously at each anchorage with the full number of links; between the summits of the piers the number was diminished to one and two links alternately. When one series of links was completed, the wedges were slacked out and the chains supported themselves. The work of adding additional links to each side of the chain was a simple process, as many as one hundred links, 24 ft. long each, being sometimes fixed in one day. When the chains were completed, the suspenders and cross girders were added, by means of a movable crane fixed upon a long base-frame weighing 5 tons, and travelling upon a temporary railway. Commencing at the abutment, one cross girder, with the corresponding portions of longitudinal girders, were fixed by it, the planking was then laid, the temporary railway carried on, and the process of fixing the next portion of the work proceeded with.

The wire cables for the Ohio bridge were made *in situ*. The wires were collected temporarily in seven separate strands for each cable; but when the wrapping was proceeded with, the strands immediately in advance of the wrapping-machine were released; so that when complete the cable was almost a solid shaft $12\frac{1}{2}$ in. diameter. This process occupied about eight months.

It will have been observed that no startling novelty is introduced in either of the bridges; each of them is the result of a tentative process. American suspension bridges appear to have been developed in much the same manner as ships' rigging. Ropes have been put in wherever they were *felt* to be advantageous, and no great heed has been paid to the inequalities of unit strain on the ropes, which theoretic investigation indicates. Indeed, as regards the *ultimate*

strength of structure, that refinement may be safely neglected, since iron wire of the quality used in suspension cables stretches so much before fracture that the several portions of the structure adjust themselves so as to take up a fair share of the work. The confidence which may be placed in a well-constructed wire-rope bridge is perhaps greater than that claimed by any other system of construction. Any undue strain on the cables of the Ohio bridge would be evidenced by a deflection of at least 10 ft., long before there was any absolute danger of failure.

One consequence of the introduction of diagonal stays is diminished pull on the anchorages, the horizontal pull of the diagonals on either side of the pier neutralising that proportion of the gross thrust. In the Ohio bridge about 45 per cent. of the gross amount is thus disposed of before it reaches the anchorages.

There has been a strong tendency in this country lately to substitute subways for viaducts and bridges; but we hope some opportunity will occur before long for the English engineers to show what they can do in wire-rope suspension bridges.

ROWAN'S MARINE ENGINES.

ABOUT ten years ago Mr. J. M. Rowan, of Glasgow, in conjunction with Mr. T. R. Horton, took out a patent for the construction of high-pressure marine engines, working expansively, and of boilers for working such engines, at pressures amounting to 120 lb. per square inch, or more. This system was a combination of all those elements which at that time were either novelties or things considered impracticable in marine engineering, but which have since then simply and gradually made their way into modern practice, and form the principal differences between this latter and the marine engineering of the past. The first of these elements is the use of high-pressure steam. We need not now repeat our own arguments about the economy and other advantages which must inevitably follow the introduction of higher pressures on board of steamers, and we only point to the general tendency of marine engineers to increase their boiler pressures. Messrs. Randolph and Elder have been working steam at 50 lb. pressure for years past with the most eminent success; other marine engineers have been following in their wake, and some are now trying to go beyond this pressure. The great improvement in marine boilers, with which our neighbours across the Channel have made such unreasonable noise, is the "inexplosible" high-pressure boiler of M. Belleville—not a formidable rival to the construction of water-tube boiler which we illustrated in our last number, and which has been constructed by Mr. J. M. Rowan for many years. This boiler is practically inexplosible, and, from every point of view, a less dangerous generator of steam at pressures of several hundred pounds per square inch than a common marine boiler is with the most moderate pressures of steam adopted from considerations of safety, although no engineer has ever been able to show why a boiler, constructed to stand a pressure of 15 lb. per square inch, should be safer at that pressure than another, which is calculated and made for 30 lb. of steam pressure, and worked at that point. The double cylinder for working high degrees of expansion is another characteristic point in Mr. Rowan's engines. It may be said that this element has not been since then successfully introduced in practice, as the recent tendency seems to be to return to the single cylinders. But upon this point opinions are far from being unanimous; moreover, there can be no use for a high-pressure cylinder, unless we have steam of really high pressure to work it. The pressures now carried by marine boilers, and those employed in the double-cylinder engines we refer to as instances of so-called failures, are utterly insufficient to justify the employment of double cylinders in that sense in which it has been intended by the advocates of high degrees of expansion, and in which it has been carried out by Mr. Rowan in a few instances, to which we intend to refer in detail hereafter. We next come to the condenser; and we find the surface-condenser, such as has gradually pushed its way into the most modern practice, applied by Mr. Rowan at a date when Hall's early experiments and failures were the only precedents for marine engineers to go by. Mr. Rowan's surface-condenser has an important peculiarity in the agitator, which keeps the water in constant motion all round the tubes, an expedient which has been proved by experience to increase the effect of a given area of tubes to a very considerable extent.

From what we know of the practical behaviour of each of these single elements, viz., the high-pressure steam, the surface-condenser, and the water-tube boiler, in the practice of marine engineering, we should have formed the greatest expectations of Mr. Rowan's system, which is in fact a combination of them all. The principles are carried in several respects much further than in present practice, and therefore all the more likely to afford advantages. Still it is recorded in the memory of the profession that Mr. Rowan's engines after a short and apparently most brilliant success have practically failed, and have, for all that is known, been abandoned by the inventor himself. But "all that is known" in this respect is very far from a complete record of the case. Engineers and inventors are not over anxious to record all the details and particulars of their failures in public, and so it follows that the "saving clauses" or the points of hope, however justified, remain untouched and unheeded. Mr. Rowan's engines have been fitted to a considerable number of vessels, of which some have failed on their first voyage, and others after a very short time of service: these have been heard of, and hence the record of failure which, as far as it goes, is indisputable. But since not all of these marine engines have been heard of as failures, the question suggests itself, what may have become of those vessels and engines which have not been heard of now for upwards of seven years? Amongst these vessels are some four or five which were built for the East Indian River Steamer Company, and engineered by Messrs. Robert Stephenson and Co., in 1860. We have before us a letter from Mr. Douglas Hebson, of Liverpool, the consulting engineer of this company, recently written in answer to an inquiry made on our behalf upon the behaviour of these vessels and engines. From this we extract the following sentences: "The last accounts I had of the River Steamer Company's boats, engines, and boilers up to the time of the great hurricane were most satisfactory. Some time prior to the engineer at Calcutta reported that the boilers were in excellent order, and likely to continue so. . . . I think the result the most satisfactory of anything that has been done yet." This testimonial from so reliable a source would in itself suffice to counterbalance a great weight of damaging evidence which has come to our knowledge. But this is not all. There is a dispatch-boat in the service of the French Government, built by Messrs. Scott and Co., of Greenock, in or about the year 1861. This vessel is 134 ft. long, 22 ft. 4 in. broad, 12 ft. 3 in. deep, 120 tons measurement, and its engines and boilers are on Mr. Rowan's plan, working steam at 120 lb. pressure. The name of the boat is "Actif," and active it has been, and remained in six years' service with the most perfect success. About eighteen months ago, after four years' uninterrupted work, the boilers were taken out for the purpose of inspection and repair; but they have been found in such excellent condition, that they have been put on board again without any alterations worth recording. We are astonished, upon seeing this mass of favourable evidence, obtained from actual experience and practical working, that Mr. Rowan has for such considerable length of time withheld all information respecting his engines to the general public; but in the history of this invention, in the light in which it now shows itself, we see only a repetition of what has happened to many another inventor before this, and will in all probability repeat itself again in all future times. The system was brought before the public before it was in a practically perfect state. The first experiments and their apparently excellent results had raised high expectations, which for their practical realisation required that earnest and careful attention to details, which the hurry and excitement of the early attempts to work on a practical scale did not afford. The causes of failures were such as would be considered out of all question at the present day. The boilers leaked—not at any special joint, but at every joint—and one of the earliest constructions of the kind, the boiler of the ship Maranham, actually became red hot at the first trip in consequence of the water having run out from this cause. The boilers primed, but so did other boilers working in connexion with surface-condensers, and recent practice has overcome this difficulty. The flues were choked with soot; but the admission of air over the grate, which had been previously omitted, overcame this difficulty. The boilers corroded to such an extent that some of those working in the Mediterranean had to be removed after a very short duration. The corrosion of boilers in connexion with surface-condensers is, however, no peculiarity of Mr. Rowan's mode of working; it has been found to take place in all kinds of boilers, and we know now that it can be easily remedied by mixing the water contents

of the boiler with a certain proportion of sea-water. It appears, therefore, that Mr. Rowan's system had been made before its time, but that gradually, by excessive improvements, modern practice has grown into a proper state to receive it. That we have great benefits to expect from its successful introduction there be no doubt. Professor Rankine's indicator diagrams taken on board the steamer Thetis for the purpose of calculating the consumption of coal per indicated horse power have given the figure of 1.018 lb. of coal per indicated horse power per hour as the consumption in actual fair work at full speed of the vessel. This is a result not arrived at by present marine engine practice, and one worth aiming at if attainable in reality. For such a reality we can at this moment produce no stronger evidence than the fact that there are steamers now running with 120 lb. of steam in their boilers, while marine engineers are discussing the question whether an increase of pressure from 50 lb. to 55 or 60 lb. will or will not exceed the limits of safety in their boiler-constructions.

LONG-PRICED IRON RAILS.

The extremely variable and often treacherous quality of iron rails, as disclosed by tests like Mr. Ashcroft's, by frequent failures in use, and by occasional accidents resulting from their breaking, has led to the advice, frequently given to railway engineers, to pay a higher price, and thus secure a better quality of iron. Price and quality seem to be almost accepted in certain minds as equivalent and convertible terms, and we read, only the other day, the recommendation of a certain authority of the "Nicholas" order to pay 13*l*. per ton for iron rails, so that they might be good. We fear that it would be much like paying 13*l*. per ton for cast-iron rails, and that the quality of the metal would not improve, no matter what the price.

In our last number, we gave the conclusion of Mr. Ashcroft's important series of tests of iron and steel rails, and many of our readers will have noticed one sample, from the Aberdare Company, for which only two years ago 7*l*. 18*s*. a ton was paid. This was a long price, yet two of these rails were broken successively, under a very moderate test, and were found to be "coarse and unsatisfactory." Captain Tyler and Mr. Eborall, in their report upon the Grand Trunk Railway, show how the Ebbw Vale Company's rails wore out in less than five years, and that a further instalment by that company, termed "steel-headed" rails, and costing 2*l*. per ton extra, would not probably last more than six or seven years. The Lancashire and Yorkshire Railway Company have experimented with the best qualities of iron they could obtain, but with little success. They have tried Beale's "boiler plate" rails, Beale's rails steamed by Dodd's process, the London and North-Western "Crewe" iron rail, Lowmoor rails, the Mersey Company's rails, Thorneycroft's "best iron," and Thorneycroft's "charcoal top." All these rails wore out in from 3½ to 7½ years (ending November, 1865), and most of them were destroyed by from six to twenty million tons of traffic. Twenty million tons, spread over 7½ years, is equal to about twenty-six trains daily of 300 tons each, gross weight, or to twice that number of trains of half the weight. Some of these rails were better than others; but the best were but moderately good, and were far inferior to steel.

DUCOMMUN'S DRILLING-MACHINE.

In October last we illustrated a very fine lathe made by Messrs. Ducommun and Co., of Mulhouse, and we then promised our readers that we should illustrate one or two more of the most interesting tools exhibited by them this year in Paris, believing, as we do, that Ducommun and Co. are one of those continental firms who will in future carry on a severe competition with English tool-makers. We also know that Mr. Steinlen, the technical manager of the firm, prides himself upon having quite attained the English standard in the matter of design, and that he is thoroughly bent upon attaining the Whitworth standard in the matter of workmanship.

In conformity with our promise, we now illustrate, on the next page, one of Messrs. Ducommun and Co.'s large vertical drilling and boring machines, capable of boring out holes of from 9 to 10 in. in diameter, and which, in some of its features, is quite different from anything that ever has been made in this country in the shape of vertical drills.

The machine consists principally of a cast-iron hollow frame, which is carried down and partly bedded into the masonry of the foundation through a depth of about 3 ft. 6 in., and provided with requisite arms, brackets, and bosses cast solid with it for carrying the spindle, the driving and the feed gear; and, secondly, of a table fitted to the front face of the frame, which is provided with *V*s, up and down which the table may slide through a height of about 3 ft. 6 in. This table is fitted with a longitudinal slide having a traverse of about 2 ft. 3 in. to or from the face of the main frame; the longitudinal slide again is fitted with a cross slide having a

traverse of about 3 ft., and this carries a turntable worked by a worm, as is the case in slotting-machines.

The driving gear consists of four-speeded cone and spur gearing, arranged as in an ordinary back-gear lathe. The method here adopted for throwing the back shaft in and out of gear is by turning it round a quarter of a revolution in eccentric bearings, an arrangement which, however, we should avoid as much as possible, on account of the tendency which there must always be for the wheels to be thrown in or out of gear of their own accord.

Motion is communicated by the cone-shaft to the boring-spindle through a pair of bevel-wheels, the ratio of whose diameters is as one to two, thus making the speed of the boring spindle one-half that of the cone-shaft. A glance at the engraving will give the reader an idea that the cone is very small for a boring-machine of these dimensions; but this apparent deficiency is entirely made up by the purchase obtained with these bevel wheels.

The boring-spindle consists of an outer cast-iron cylinder, carried at its upper and lower extremities in conical bearings fitted into the projecting arms of the frame; these bearings are made adjustable by means of nuts and lock-nuts, in order to admit of taking up the play which is occasioned by wear through friction. This outer cylinder is fitted with a wrought-iron spindle, which may slide up and down in the former, and at the same time is made to revolve round with it by means of a feather fitting into a slot or groove provided in the wrought-iron spindle throughout its length.

The feed is communicated to the boring-spindle, either by hand or by self-acting process, by means of a pinion gearing into a rack which presses upon a steel pivot fitted into the top of the wrought-iron spindle, and held secure in it by means of a screwed bush. This pivot may be oiled from the top of the rack through a central hole with which it is provided. The rack is made half cylindrical, and a little less in diameter than the boring-spindle, and may, consequently, be made to slide down in the outer cast-iron cylinder above described. Motion is communicated to the feed-pinion through a vertical shaft, which carries at its upper end a worm, gearing into a worm-wheel fixed upon the axis of the pinion; at its lower end this shaft, which is carried in bosses cast on to the frame, is fitted with a hand-wheel which is keyed to the shaft, and with a worm-wheel which runs loose upon it, but which may be fixed to the hand-wheel by the friction of a *V*-headed bolt fitting into a corresponding groove in the worm-wheel and passing through a boss cast on to the hand-wheel: when the nut of this bolt is drawn up tight, the worm-wheel and hand-wheel, and consequently the vertical shaft, must revolve simultaneously; when, on the contrary, the nut is slackened, the hand-wheel and the shaft may revolve while the worm-wheel remains stationary. The self-acting feed-motion is communicated through this worm-wheel by means of a worm keyed upon a horizontal shaft, which is driven from the cone-shaft by a strap running upon a pair of small cones.

The vertical traverse of the boring-spindle is about 1 ft. 8 in., and its horizontal distance from the face of the frame is about 2 ft. 9 in.

The weight of the boring-spindle and rack is balanced by a counterweight suspended to a rod descending into the hollow frame, the connexion between this rod and the rack being made by means of a lever having its fulcrum upon a bracket bolted to the top of the frame.

A boring-bar may be passed through a guide or boss in the table for boring out holes of a large diameter, or situate at too great a distance from the lower bearing of the spindle to admit of accurate and smooth boring.

The table is moved up or down by means of a screw passing through a nut fitted into the foundation plate of the machine, and set in motion through a pair of bevel wheels by a short cross shaft, which itself is driven through another pair of bevel wheels by a short longitudinal shaft moved by a hand-wheel. The top of the screw is steered, and the pressure upon it is taken up by a steel pivot fitted into the table, and provided with an oil-hole running right through the centre of it, so that it may be oiled from the top face of the table.

The longitudinal and cross slides are respectively set in motion by means of screws in the usual manner. The turntable is kept in position by means of four adjustable brackets or guides, dipping a conical face turned on the upper edge of the worm-wheel of the table.

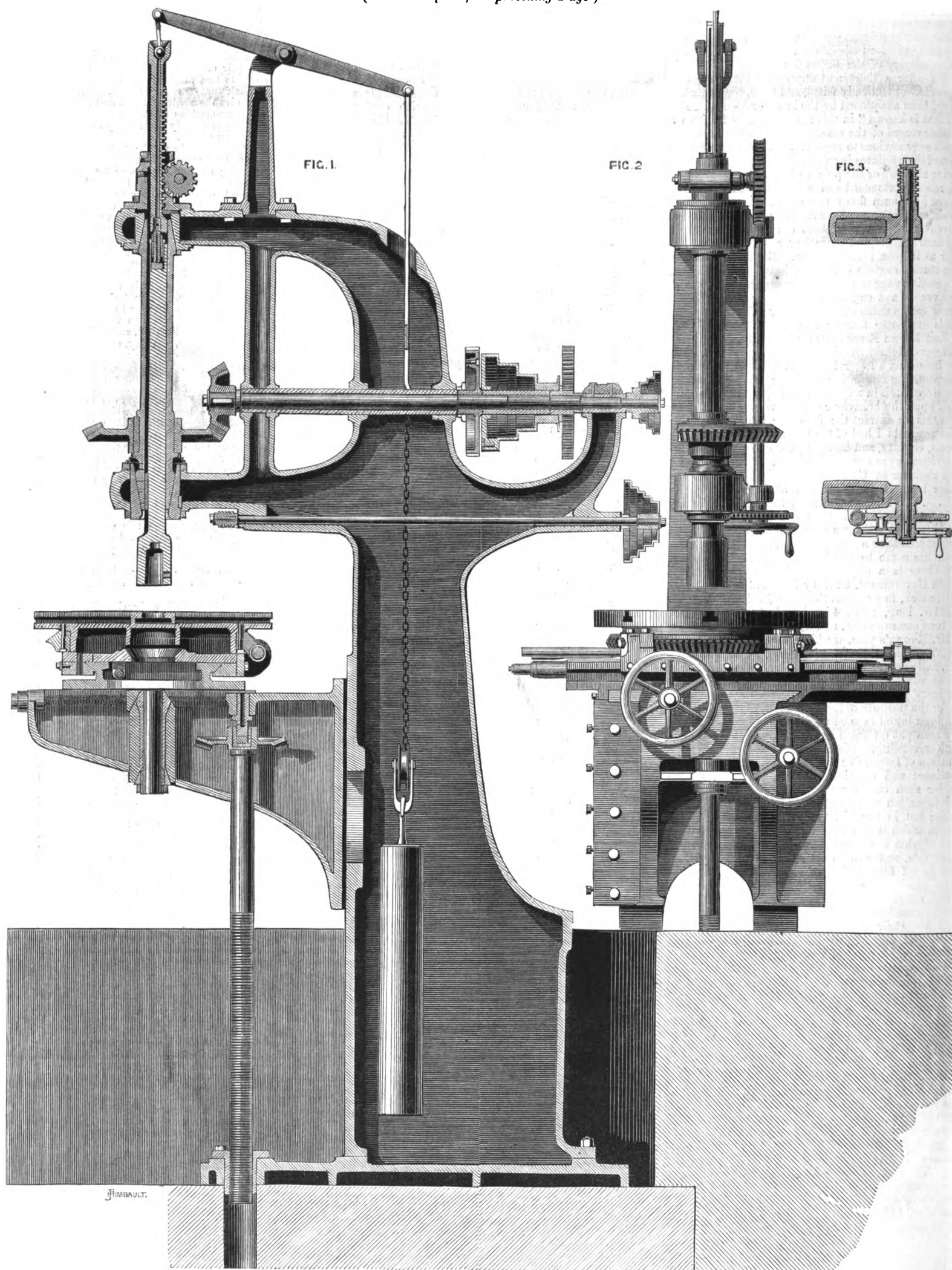
All the bearings in this machine are bushed either with brass or with close-grained cast iron or case-hardened wrought iron. Great stress is laid by Mr. Steinlen upon the superiority of this construction as compared with the practice which is gradually gaining ground in England of dispensing with bushes altogether for the sake of cheapness—a practice which is but another proof of the downward tendency of modern engineering in some of its phases.

The peculiarity of this machine, it will be observed, rests in its being provided with longitudinal slide, cross-slide, and turntable, a profusion of sliding-tables which is not to be found in any English drilling-machine, and which certainly seems useless at first sight. The machine, however, has been specially ordered in this shape by "Le Creusot," for the purpose of hollowing out the shank ends of wrought-iron eccentric straps by means of rose bits. In this country this is generally done upon a lathe specially arranged for backward and forward motion, and we are inclined to think that this is the cheapest and most expeditious mode of doing this work; but when it is remembered that in France the wages of a machine-man are in some cases only one-third that of a good turner, it is quite possible that in that country it may be done cheaper upon the drilling-machine.

A "GRADING" MACHINE.—A new so called "grading" machine is at work on the Fox Railway, Illinois. It consists of a plough with an apron and gearing for carrying the earth up and depositing it in the centre of the road bed. It is worked by four horses and two men, and will do the work of thirty men in preparing the inclines.

VERTICAL DRILLING AND BORING MACHINE.

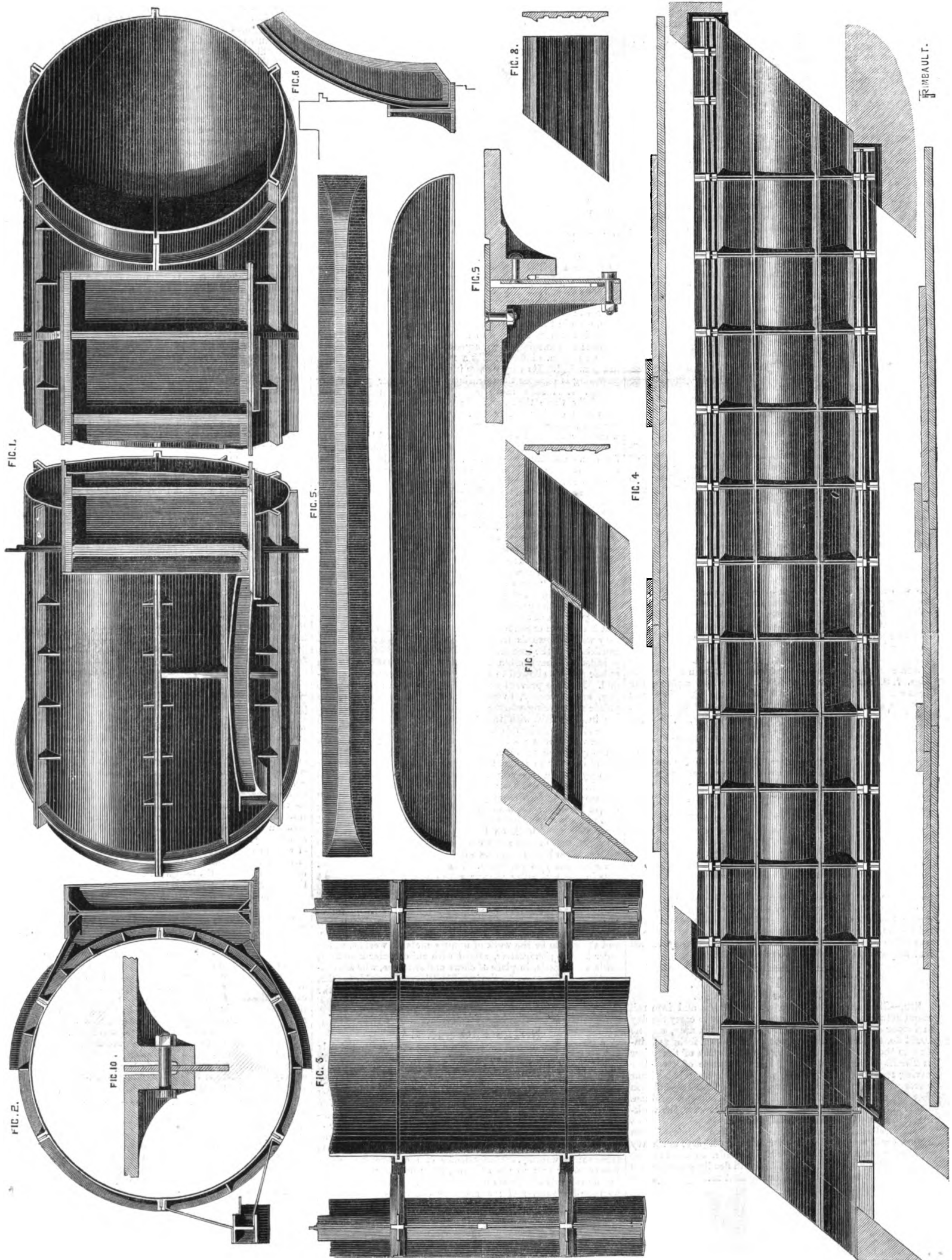
CONSTRUCTED BY MESSRS. DUCOMMUN AND CO., ENGINEERS, MULHOUSE.

(For Description, see preceding Page.)

SEWER CROSSING AT SLOANE-SQUARE; METROPOLITAN DISTRICT RAILWAY.

MR. JOHN FOWLER AND MR. THOMAS MARR JOHNSON, ENGINEERS.

(For Description, see following page.)



THE RANELAGH SEWER CROSSING.

THE construction of the Sloane-square Station of the Metropolitan District Railway involved, amongst its other works, the destruction of a length of the Ranelagh sewer, and its restoration in the manner illustrated on the previous page. The centre line of the sewer crosses that of the railway at an angle of 48 degrees, nearly at a point where the clear distance between the station walls is 60 ft. on the square. The length of sewer which has to be supported upon girders and carried over the rails is therefore a little over 66 ft.

The cast-iron tube which has replaced the old brickwork is supported on two wrought-iron main girders, and on two smaller girders of cast iron, which span the staircase constructed at the back of one of the retaining walls of the station. It will be seen that the tube is made up transversely of six segments, which vary in thickness from $\frac{1}{4}$ of an inch at the crown to $1\frac{1}{2}$ in. at the invert. The segments are 5 ft. 11 in. long, except at the end where the difference of the skew is made up, as will be seen in Fig. 4; and they are stiffened on the lower side by intermediate longitudinal webs, in addition to the flanges by which they are bolted together. These are, however, omitted in the upper half, where the plates have but little work to do. Longitudinally the joints are made by flanges $1\frac{1}{2}$ in. in thickness, and $\frac{1}{2}$ in. bolts, pitched 4 in. apart, are used throughout, the joints being made good with canvas and red lead. Figs. 1 and 2 show the general construction of the tube, with the arrangement of the transverse and longitudinal flanges, feathers, &c. It was considered necessary to provide for any occasional variation in the length of the sewer crossing, and one joint is arranged as shown in Fig. 9, by which expansion and contraction are provided for. It will be seen, by reference to the section, that the end of one length of the tube is countersunk to the depth of $\frac{1}{4}$ an inch for about 3 in., and that the adjacent length has a corresponding recess. A wrought-iron ring, $\frac{1}{2}$ in. thick, is fitted to the countersink, being bolted to one length of the tube, and left free to slide in the other. Externally, one connecting flange is increased from a depth of 5 in. to 9 in., the other being left the ordinary length. A wrought-iron disc, $\frac{1}{2}$ in. thick, makes the joint good, it being bolted to both flanges, and packed with two rings of india-rubber. The position of the expansion joint is shown on the side elevation (Fig. 1), and the sectional plan (Fig. 4). Behind the retaining walls the iron tube is built into the brickwork of the sewer, which was reconstructed for a short distance on each side.

The main supporting girders are of wrought iron, 73 ft. 8 in. long, 6 ft. 6 in. deep, with a width of top and bottom flange of 1 ft. 10 in. and 2 ft. respectively, the former being stiffened with an angle iron rivetted along the outer edge. They are of the ordinary type, excepting that while the stiffeners on the outer side are of the same width as the top flange of the girder, and are strengthened at the edge with light tee iron, on the inner side they conform to the contour of the sewer tube, and are bolted to it at every transverse flange junction. This arrangement determines the distance between the stiffeners to be 5 ft. 11 in. Fig. 2 shows clearly the junction between the sewer tube and girder, and it will be seen there that the tee iron by which the stiffening plate is rivetted to the web of the girder is extended not only around the tube, embracing it above and below, and fastened to it by the same bolts which secure the flanges together, but also forms a part of the corresponding stiffener in the girder on the other side of the sewer tube. By this means the whole structure is securely bound together. Fig. 10 shows an enlarged detail of part of this connexion. Each main girder has a bearing of 3 ft. 8 in. on cast-iron bed-plates, shown in plan and section, Figs. 7, 8, the former of which includes also a plan of the light cast-iron girder which steadies the tube where it crosses over the staircase. The distance on the skew is 8 ft. 2 in., and the girder is connected with the sewer only by a light iron strip, 3 in. by $\frac{1}{2}$ in., Figs. 1, 2, 4.

The wrought-iron principals which carry the roof of the Sloane-square Station spring from a level above the crown of the tube, and a cast-iron girder, Fig. 5, spans the space on each side out into the station walls for the passage of the sewer crossing. Fig. 6 shows the section of these girders, and the method employed for attaching the roof principals to them.

This work was commenced about twelve months ago, when the length of sewer since reconstructed was cut away, and the sewage was carried in a wooden trough, supported at various points throughout its length upon trestles which rested on the rail level beneath. The iron tube was constructed around this trough, the girders being put in first on each side, and the invert plates built in place below it. As these were secured to the girder, the trestles were removed one by one, until the temporary trough rested entirely on the girder blocked up upon the invert plates of the sewer. The tube was then completed, and the trough enclosed before it was taken to pieces, and the sewage was ultimately turned into its permanent channel two months ago.

STEEL AND IRON RAILS.

TO THE EDITOR OF ENGINEERING.

SIR,—Steel rail makers on the one hand, and iron rail manufacturers on the other, are each anxious to carry the day in favour of their own material. Both parties may, and no doubt do, to a certain extent, permit interested feelings to influence their judgment. Hence the exultation of the writer in *The Engineer*, of 13th inst., in consequence of a splinter having separated from a steel rail at Charing-cross. Your correspondent, "Ironmaster," gave a similar instance, and then there was the Chalk Farm rail, only broken by a collision. These three steel rails form at present, as it were, the working capital of the Anti-Steel Rail League.

One steel rail broken by collision, and two splintered from causes I will explain, led neither to death, injury, nor heavy claims for damages. Not so with iron rails, so tried and so trusty. Many of these have failed with deadly consequences to life, and leading to heavy claims against railway companies for compensation.

No doubt the Anti-Steel Rail League have brought forward all the steel failures they could find. At present the sum-total of ascertained breakage consists of one steel rail broken by a collision, and two other steel rails each splintered at the one end through the bolt holes for 20 in. in length, the splinter in each case retaining its position between the fish-plates, and causing no damage to either train or passenger. One of these splintered rails, viz., the Charing-cross rail was, immediately after its breakage, tested, and it stood proof well, as even the *The Engineer* writer admits. Why then did the splinter detach itself from the body of the rail? The reasons are very simple. The rail, bloom had been overheated, i.e., "burnt," as it is termed, at the splintered end, and the punching of the $1\frac{1}{2}$ in. bolt holes had weakened the steel, already deteriorated by the overheating of that end of the rail bloom. Moreover, it appears that the rail in question was more carbonised, and therefore harder than the other steel rails laid with it, and in consequence it would suffer more from overheating, and be less tough subsequently than it would otherwise have been. Hard as it was, however, it was sufficiently tough for a rail, and would never have broken except from a violent concussion, had it not been weakened at the one end by overheating and from the punching of large bolt holes. Now no manufacturer need overheat his blooms so as to burn them, and a burnt end can always be detected, and no maker of steel rails would any more burn his steel than he would set fire to his own house.

Accidentally a bloom may be overheated; but it is far easier to avoid this than to do it, for it takes a very high heat to injure a rail of Bessemer steel, and such a case must be very rare. Now an iron rail would, if it broke at all, have broken quite through, and an accident would in all probability have occurred, so that the Charing-cross steel rail affords in reality a proof in favour of steel, as compared with iron, even in the degree of its partial failure.

I think it would be well to drill the bolt holes in steel rails in place of punching them, especially when the holes are so large as $1\frac{1}{2}$ in. diameter. As a rule, steel should be drilled, not punched. Its very nature indicates this. But no doubt punching is cheaper than drilling; and whether punched or drilled, steel rails mean safety, and iron rails danger, especially those that are made and sold at present prices. Iron rails, costing 12l. or 13l. per ton, have been laid down ere now; but were they as good as steel rails? If iron rails were now supplied at 12l. per ton, they would be made, at least their tables would be made, of iron brought out "young" from the puddling-furnace, or, in other words, of puddled steel; yet these would not be so good as Bessemer steel rails, for the simple reason that puddled steel is not so homogeneous as cast steel. Let the advocates of iron rails make a perambulation on foot along railway lines laid with iron rails, and count the number of crushed, laminated, ragged rails, and they will be sensible that if the argument of want of uniformity can be brought forward as telling against the use of steel rails, the utter want of uniformity palpably evident in the iron rails ought for ever to exclude them from the formation of anything termed "permanent way," unless that term is to be used in just as "*lucus à non lucendo*."

Let the uninitiated passengers who, in good faith, commit their lives to the perils of the permanent way, walk along the railway lines and examine the faulty iron rails which abound; and if they are capable of reasoning as to cause and effect, they will afterwards feel a little nervous about the trustworthiness of the iron rail.

Indeed, I have often thought that the reason why the public are not allowed to walk on the permanent way is twofold. First, to prevent accidents to those who walk on the line, and, secondly, to prevent, as far as practicable, the public from seeing what a multitude of damaged rails there are in lines laid with iron. Now where steel rails are laid none of this deplorable want of uniformity is to be found. Those who would go back from steel rails to iron rails because good iron rails can be made, but are not made, because it will not pay to make them, would probably take another step further in the retrograde direction, and return to the primitive wooden rails and wooden wheels.

I can assure your correspondent "Cancer" that the "bite" of wooden wheels on wooden rails is very great, and at a speed of 3 miles per hour locomotion with these would be safe, and the stoker could walk on before to see that the timbers were all right, and to lead stray cows off the line. We might in time come to have engineers with wooden heads, even if such are not already in existence. The drawback, however, consists in the molecular change called dry rot, which might affect both wheels, rails, and brains.

Cannot the prophets of evil in the matter of steel rails investigate the molecular mystery? Possibly a powerful microscope of the double achromatic imaginative class might reveal the origin of the molecular deterioration of steel rails, and show it to be the work of minute metallic weevils, of the order *Teredo ferrirostris*, armed with animalcular hammers, drills, and chisels, in place of claws and antennæ, who are diligently working away for the benefit of the makers of iron rails, and for the express purpose of verifying the predictions of the writer in *The Engineer*.

Cheltenham, Dec. 21, 1867.

ROBERT MUSHET.

NOTES FROM INDIA.

Bengal.—The debt of India in the year 1840 amounted only to 34½ millions sterling, but by 1856 it had increased to 57½ millions; the mutiny raised it to 98 millions in 1860, and it may now be taken at about one hundred millions, or less than two years' income, a much smaller proportion than in any other country. The charge for interest has increased from 1,595,778l. in 1840 to 4,482,385l. in 1865—a quarter of a century; the interest, therefore, averages about 4½ per cent. The calamity of the 1st of November last, notwithstanding the warning and promises of 1864, again found the arrangements of the Calcutta Observatory wanting. Timely notice of the impending storm was certainly sent to the shipping, but the observations made during the gale itself were most imperfect. Not only was there no record whatever of the magnetic conditions prevailing at

the time, but the anemometer has again failed to register the force of the wind. In 1864 it was carried away after registering a pressure of forty pounds, but on the 1st ultimo it is said to have been carried away without registering anything at all.—Some time since the Supreme Government represented to the Bengal Government the desirability of conserving ancient architectural remains, and of having them systematically photographed; a letter to the same purport has been sent to the Madras Government, with the request that lists of the architectural structures and works of art in each district may be drawn up.—Lieutenant T. C. Manderson, R. E., at Subathoo, has recently filed a specification of an invention for an improved method of manufacturing artificial stones of various sizes, either plain or ornamental, for building purposes.

Central Provinces.—Sir Richard Temple has been making a tour in Berar. After leaving Shegaum the train went on to Akola, before reaching which, however, he was doomed to see something of the Great Indian Peninsula Railway Company's broken-down bridges, of which there are so many in Berar. Between Shegaum and Akola there are now so many either under or out of repair, that all trains have to stop and then proceed at a walking pace.

North-Western Provinces.—Allahabad is rapidly becoming a town of rising importance, and bids fair to eclipse its old rival, Agra, and become the first city in the North-Western Provinces. The new building for the High Court is said to be now in an advanced state, and the engineer in charge expects to have it completed by the month of January or February next. It is also stated that the East Indian Railway Board is to be transferred permanently to Allahabad; and a site for the offices required was recently discussed at a local municipal meeting. Allahabad now forms a central railway terminus between Delhi, Calcutta, and Jubbulpore; while the link that will connect Jubbulpore with Bombay will be completed in no great space of time.—Mr. Wilson's light railway, at a cost of under 6000l. a mile, is to be at once begun, in continuation of the present line from Lucknow to Byram Ghaut and Fyzabad, and thence to Benares; the line will thus connect the four great cities of Benares, Fyzabad, Lucknow, and Cawnpore, and ought to pay splendidly. There is no reason why it should not be completed in two years.

There remains the question of the Ganges bridges to connect the Oude line with the East Indian Railway at Cawnpore and Benares; but it is probable that an experiment will be made at Cawnpore by the erection of a temporary wooden bridge for 20,000l., until the question of permanent structures has been decided.—On the recommendation of the Director-General of the Post-Office, the Government of India has sanctioned the establishment of a bullock train at Darjeeling. The principal stations will be at Julpigore, Minagore, Saligore, and other important places along the Darjeeling road.

Punjab.—The Punjab Railway Commission have submitted their report, in which they condemn Colonel Elphinstone in most of the *laches* laid to his charge, and they maintain that he has infringed in several instances the terms of the contract between the Punjab Railway Company and the Secretary of State, that the company have suffered was by the unsatisfactory character of the contracts he entered into, and that his selection of *employés* was not to the advantage of the company. The Governor-General has added a minute adopting the very unfavourable conclusions of the report. The new Sutlej Canal works have, it is stated, been now commenced. The canal will leave the left bank of the river near Roopur, and passing southwards irrigate the arid parts of Puttiala, Ferozepore, and Sirsa.

Madras.—The Madras papers state that at Madras there were no other symptoms of the late cyclone than a rather rough and shifting wind. The ship *Blenheim*, which left Madras for Calcutta on October 18th, was caught in the storm 500 miles east of Madras, and she was consequently obliged to put into Cocanada on November 10th in a helpless condition. Mr. Dalsell, of the Civil Service, has lately drawn up a report on the famine which devastated the Madras Presidency in 1866. In it he suggests that yearly loans should be raised to construct new irrigation works, and to keep the present ones in good working order; he shows that an amount of land, which now lies waste, will be brought under cultivation, the revenue derived from which will be more than sufficient to pay the interest accruing on these loans, allowing the balance to be placed in a sinking fund for the ultimate liquidation of any obligations that may be contracted by the Government or private enterprise. The prosecution of public works in the province of Mysore is very unsatisfactory. About 17½ lacs was spent during the year 1866-67, of which no less than 8½ lacs was for "establishment," about 7 lacs only for "communications," 329,813 Rs. for "civil buildings," and 288,436 Rs. for "agricultural works." Seeing that the crying want of Mysore is "communications," it is unsatisfactory to find the Government content with spending a paltry 7 lacs on them, one-half of which has to go for repairs.

Bombay.—The completion of the portion of the new Eastern Boulevard, from Bazaar Gate-street to the Elphinstone circle, has been sanctioned, and Government have ordered the work to be commenced at once. The revised plan necessitates an alteration in the boundary wall of the Great Indian Peninsula Railway terminus, and it is estimated to cost 58,216 Rs.—A steam boiler at the Patent Ice Factory, Bombay, burst some days ago, causing the death of three persons and injury to others; and on the 26th November some turpentine caught light at the Government dockyard, and some shedding became on fire. The fire was at once got under, but one man was killed, and several were dreadfully injured, through the accident, of whom four died at the hospital. In October last, 9,802,352 lb. of cotton were shipped from Bombay of the declared value of 3,223,950 Rs., or very nearly 8d. per lb.—The steamship *Krishna* on her last voyage from Suez to Bombay burnt 600 tons of coal, which had been brought from Europe by way of Port Said and the Suez Canal.

Ceylon.—The railway has been in a chronic state of interruption for some time past, so far, at least, as the traffic on the incline is concerned. Now that the burst of the monsoon is over, more regularly and a return to the usual traffic arrangements is naturally looked for, but at present the complaint is that facilities by rail are far less than by the old coach, especially for the postal service.



Yours faithfully
R. Napier

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ENGINEERING.

FRIDAY, DECEMBER 27, 1867.

ENGINEERING IN 1867.

THE record of the engineering undertakings completed or prosecuted, or even begun or projected, during the year now passing away is not a long one, nor does it bear comparison in its importance with those of many previous years. Nearly all new engineering undertakings are necessarily speculative in their nature, and never was capital more distrustful of speculative enterprise than now. Accustomed to continual and rapid progress, the engineer finds scanty satisfaction in the retrospect of a year so little marked by novel schemes or the advancement of large and numerous works.

Here, in London, several large and important works, begun some years ago, have made steady progress, and the metropolitan main drainage has been nearly completed, at a total cost of about 4,000,000l. The Thames embankment, on both the north and south sides of the river, has been pushed forward at a fair rate. The works of the Metropolitan District Railway, of the new Smithfield Market, of Blackfriars-bridge, and the Midland Railway extension to London have also gone forward, but with less activity than that to which we were accustomed before the great collapse of two years ago. All these works have been so often and so fully described in our pages that we need not repeat particulars of them here. We may say that, in some form or another, nearly fifteen millions worth of engineering work is in progress or near completion in and near London.

In the provinces, the larger railway companies are almost always spending considerable sums in new works, but none now in hand are of special interest, unless it be the Runcorn bridge of the London and North-Western Company, over the Mersey—a work of three spans of 300 ft. each, and now nearly completed. Several interesting works already projected—including the new line to Brighton, the tunnel under the Mersey at Liverpool, the line of the London and North-Western Company from Chapel-en-le-Frith to Sheffield, with two tunnels, the one three and the other four miles in length—have been abandoned; and the unfortunate Waterloo and Whitehall line has long been at a standstill. This line would have afforded one of the most interesting applications of the pneumatic system, it being planned as a tunnel of iron cylinders sunk across the bed of the Thames. It was, we have no doubt, in bad hands, since the engineer has from the first been unable or unwilling to answer any question touching the dynamical results of the application of his system of blowing and sucking through pneumatic tubes—a system which, as carried out upon his plan, necessarily involves a great waste of power. The Holborn and Euston pneumatic post line, 1½ miles long, remains

unused pending the extension of the tubes across the Holborn valley to the General Post Office.

Abroad, we find but a moderate progress in engineering works. The railway over the Brenner Pass of the Alps has been opened; but that over the Mont Cenis still haunts fire, in consequence, as is widely believed, of the unfitness of the Fell system for its work. The Mont Cenis tunnel meanwhile makes fair progress, considerably more than half of its length being already completed.

In mechanical engineering, the year has been signalled by no striking discovery of promise. We cannot say that any marked progress has been made in marine engineering, unless it is that engines of still larger dimensions are being made, notably those of the Hercules and the Monarch, the former with 127 in. cylinders and 4 ft. 6 in. stroke. No attempt has been made to adopt higher pressures of steam at sea. Surface-condensation, superheating, expansive working, counterweighting, high piston speeds, balanced slide-valves, the use of liquid fuel, all may be said to have remained in *status quo*, there having been no substantial progress to record. The water-jet propeller has shown no advantage over the screw, but rather, in the present form of its application, a considerable inferiority. Mr. McFarlane Gray's steam-steering gear marks a minor stage of progress, and it is likely to come into extended use.

In railway engineering we have had little to note beyond the extended substitution of steel for iron rails. In locomotives no notable change has gained adoption, although there is a growing disposition to employ the four-coupled engine with a four-wheeled Bissell bogie. Mr. Fairlie's double-bogie engine has attracted increased attention, and Captain Tyler has unhesitatingly recommended it for adoption upon the Grand Trunk Railway of Canada, which is equivalent, of course, to recommending it generally for all heavily worked lines. Mr. Burnett's heavy passenger engines, to work the Metropolitan and St. John's Wood engines, deserve perhaps a word of remark. Built to work a ¾ mile incline of 1 in 27, with a station halfway up, they have six-coupled wheels, 4 ft. in diameter, 20 in. cylinders, 2 ft. stroke, and weigh, in working trim, 44 tons. Touching railways, we may note that the general adoption of train signals between the passengers and guards is now likely to be effected at an early date under an Act of Parliament.

We have dealt, in another page, with the improvements made during the year in the manufacture of iron and steel.

In telegraph engineering we have to record the laying of a cable between Florida and Cuba, thus completing a telegraphic line from London to Havana.

In agricultural engineering, which promises perhaps the finest future of any branch of our art, improved results are being attained with the eight-furrow plough and the very wide cultivator, and it is likely that the double-engine system of steam tackle will yet be generally made so that both engines may work continuously, and drag two implements at the same time, say two of different kinds, as a plough and a cultivator, or two of the same kind, working, one after the other, at different depths. The report of the committees of the Royal Agricultural Society upon Steam-cultivation marks an important event in the history of steam-tillage, to which it has already given a marked and valuable impulse.

The most interesting event of the year has been afforded by the great French Exhibition. Our own country was not as fully represented as could be wished, but in the engineering and mechanical branches we were not surpassed in quality. The Continental engineers showed, however, that they had made remarkable strides since 1862, and especially since 1851, in respect of excellence of workmanship, and they have already excluded us from many markets formerly our own. This fact has been somewhat indirectly ascribed to the more systematic technical education which prevails upon the Continent, as compared with our own country, but it is really due to the greater cheapness of Continental labour. Although we have no wish to underrate the importance of technical education, it will be a great mistake if we allow it to distract our attention from the prime importance of cheap and contented labour. Capital must provide not only employment for labour, but cheap and good homes and cheap and good food for it as well. The waste now tolerated in the prime necessities of life, merely from the want of systematised arrangements by masters—a want growing out of a false feeling of independence both on the part of masters and of men—is beyond belief, and, unless remedied, it may go far to undermine the best interests of British industry, now that they are so sharply assailed from abroad. The whole question of

international competition is now solely one of the cost of labour, the relative advantages of skill, raw materials, &c., being practically equal. The disclosures by the inquiries of the Trades' Union Commissioners present one of the least hopeful aspects of the labour question. Industry can never be in a healthy state while secret organisations and intimidation are permitted. It is but a step beyond Fenianism; and the detestation with which this form of secret plotting and action is now viewed, and the energy with which it is being put down, may go far to discourage those other conspiracies against the best interests of labour.

The commission of inquiry into the water supply of the metropolis has resulted in the recommendation to leave the sources and appliances of supply much as they are. The gas question is still unsettled, but it is certain that a considerable reduction must yet be made in the price of gas; and it is probable that the main portion of the metropolitan gas supply will be made some distance down the Thames, and sent into town through mains of corresponding length.

The enforcement of the exclusion of sewage from the Thames, above London, will no doubt improve the river in respect of the purity of its water, and much will be gained when all sewage and the foul discharge of factories, &c., is carried over the land.

The enforcement of the Smoke Prevention Act in the provincial towns is already being attended with good results.

Artificial stone is becoming more and more employed by engineers and builders, and with the best results. Its permanence, adaptability, and cheapness are likely to bring it into very extensive use.

A minor yet useful improvement of the year is that of the introduction of steam road-rollers for rolling macadam roads to a smooth surface. It will be wondered, at some future time, how we ever tolerated such barbarous roads of broken stone as have so long disgraced London.

We have said nothing of ordnance and armour, but the subject has scarcely presented any new aspects during the present year. We have not learnt how to make stronger or better guns, nor have we in any way altered our plans. We have experimented with the 15 in. Rodman gun to learn that with 100 lb. of powder it can effect the penetration of the Hercules target, as can also the Palliser chilled shot fired with 43 lb. of powder. Nothing has been done to show that the American system of ordnance is as good as our own, nor is it at all certain whether their guns could continue to withstand the heavy charges with which only they are able to send their shot through our thickest targets.

Science has lost one of its greatest lights this year in the person of Professor Faraday, and another eminent disciple in the Earl of Rosse. In our profession we have to record the deaths of Robert Hawthorn, locomotive engineer, of Newcastle, Edward Humphrys, marine engineer, M. Perdonnet, the eminent French engineer, and others of lesser note.

May the coming year show greater progress, and be attended with greater prosperity than the last!

LABOUR REFORM.

THE amount of money paid, every year, as wages to male and female workers in the United Kingdom has been estimated by Professor Leone Levi at more than the whole cost of our railways, and as more than half of the national debt. Professor Levi estimates that there are 10,697,000 "earners of wages" in the United Kingdom, of which 5,523,500 are males over twenty years of age, and the yearly total of wages earned is put down as 418,300,000l. Of this vast total 47,000,000l. are set down to textile manufactures, 31,500,000l. to metal manufactures, 27,700,000l. to shipping and railways, 42,500,000l. to the building trades, and 15,000,000l. to mining. Agriculture is held to be the largest employer of labour, paying 75,000,000l. yearly, while no less than 60,000,000l. are set down to domestic service. That this estimate is much beyond the truth we have no doubt, inasmuch as it gives nearly 40l. a year, as wages, to each worker, male and female, and whether over or under twenty years of age. But even were the total one-fourth less, and were it possible to economise 20 per cent. of this by means of an improved organisation of labour, placing it in a better and more intelligent relation to capital, the national saving would be 60,000,000l. a year. The advantage that such a saving would afford us in competition with other nations would be far greater.

No saving in the cost of labour is to be effected, however, by depriving workpeople of any of their present comforts, nor by lessening their ability of

laying by something for the future. Indeed, they might, and should, live better and happier than now, and that for much less money—not by any new economy or unusual thrift or management of their own, but by the enlightened co-operation of their employers, and the advantages which the capital of employers, judiciously directed, would secure. Workmen, any more than any of us, do not gain by what they *spend*, but by what they *save*; yet the present relations of capital and labour turn the workman over to the mercies of house-building speculators and landlords, and to shopmen and middlemen of all kinds, who, producing nothing themselves, live upon him in fifty ways.

How is it that the queen can always command the services of 250,000 soldiers and sailors for a mere pittance per day? In France, more than half a million wiry active men, who, if trained, would make excellent workmen, serve in the army at from 1d. to 2d. per day, taking, as we may say, an eight years' engagement at that. It is merely because these men know that they are permanently provided for—that they are to have no dealings with landlords and shopmen—nor, in sickness and death, with doctors and undertakers, seeking a 5% or a 10% "job" out of what should not bear a prime cost above half-a-crown.

Workmen, we know—and, indeed, all of us—are averse to anything like "paternal government." Yet all its advantages (and these really are many and substantial) may be secured without its disadvantages. It is the awkwardness—or, worse, the offensiveness—of official or organised interference—even when inspired by the best motives—that makes it so hateful to the governed. It is especially when this interference is exercised by beadles, and overseers, and other underlings that it is most hateful of all. If employers wish to gain the confidence of workmen—and it would be worth untold sums were they to do so—they must treat them in some measure as equals, conferring and deciding with them as if they were partners, at least in some things. And cheap and willing labour is better than a great contract. Nor do masters know how impossible is labour, if workmen can only see reason, kindness, and sincerity on the part of capital.

Workmen are bled more freely by landlords, shopmen, and middlemen than by all else. Masters should take care, especially in establishing manufactories in new places, to obtain the control of sufficient freehold land for their own workmen, and to burn bricks and erect dwellings for them, to be rented at, say, 8 per cent. upon the cost price. At this rate a pair of very good and comfortable two-story houses might be built for 160%, and let for 2s. 6d. a week for each dwelling. In a little town of houses like these there should be a wholesale market, a flour-mill and bakery, waterworks, gasworks, a brewery, a hospital, &c., all owned by the employers of labour, and guarded in every way against the extortions of speculation. Everything should be done to discourage shopkeeping and middle-men, for a retail shop is the most costly and blundering medium of interchange of which we can conceive. The trade expenses of little and contemptible businesses add enormously to the net price of the goods to the consumer. There should be churches and chapels too, with free worship for both churchmen and dissenters, and there should be schools with a nominal charge for instruction. A large manufacturing concern should have a large farm of its own, well placed, and sending supplies of vegetables, fruit, poultry, butter, cheese, and eggs, and this farm should be open to occasional cases of workmen requiring change of air or occupation. There should be an asylum, too, not too far from the works, yet well in the fresh country air, for superannuated workmen—a sort of Chelsea or Greenwich Hospital for old pensioners, who should, in the interests of labour, be as well looked after as the youngest and strongest men.

We are aware how new and, in England, at least, how unprecedented are these means of rescuing British industry from the great danger which now threatens it—the great danger of being swamped by the equal skill and cheaper labour of the Continent. Capital and labour must co-operate closely and intelligently, and every effort must be made to erect a self-contained colony in each scene of labour. The arrangements which we have suggested must be effected by capital, at a charge of not more than 5 or 6 per cent. for the interest upon the capital employed. Committees of masters and men—the latter having the right of substantial appeal—must be formed under each general head of expenditure, and all the reforms proposed must be carried out with the perfect co-operation of masters and workmen. A course like this, by diminishing the unworthy gains of landlords, shopkeepers, and other non-producers, would soon have its effect upon the economy and comfort of British labour.

ABYSSINIA.

THE pioneer force of the invading army have recently been busy in exploring the approaches from the plains to the highlands. One tour of this character, which occupied ten days, was round the head of Annesley Bay; and the result thereof has established, beyond doubt, that there is no means of access into Abyssinia, for even a small body of men, between Arifila, some five hours' march from Zoula, and Upper Ragule—a distance of at least sixty miles along the eastern slope of the mountains over against Zoula. Latterly, the Koomayloo and Huddas passes have been undergoing examination, as being apparently the most promising route for conveying troops, on their arrival, away from the hot plains of Zoula to some station near Senafe. The Sooro pass is already being operated upon by the Sappers, to protect whom a body of Native Infantry hold the head of the defile. This work is imperatively required, in order that the troops, on their arrival, may be speedily removed from the evil effects likely to be caused by the rains, were the men detained in the lowlands. The necessity, for the present, of detaining in the Red Sea all vessels fitted with condensers is very important. The formidable and serious difficulty of providing sufficient and suitable water is now in a fair way to be overcome; but until the Sind Brigade shall have landed, and been moved up to the Wad rivulet, or to some stream that may be found in the bed of the Huddas, there will be some cause for anxiety.

A long stone bunder, in course of erection at Mukutto, is nearly finished. The line of rail which, for the present, is to be worked by trucks drawn by mules, is rapidly attaining length, under the energetic superintendence of Captain Leslie, commanding the Bombay Sappers. It is destined to connect the landing-point with the body of the camp, some two miles distant. Sheds also are building on the beach, near which large quantities of stores have been stacked. The railway will be a great boon for all connected with the Land Transport and Commissariat departments; for the road to the camp is nothing but a weary track of sand, very uncomfortable to traverse on foot during the heat of the day.

The last accounts from the ghauts report the so-called passes as barely practicable. In places the rocks close in so that, by the sudden rains, the defiles fill almost instantaneously to a height of several feet, which would render it, of course, a matter of extreme danger were it attempted to pass an entire army through continuously. All the roads leading through the mountains are reported, at present, as unfitted for the passage of a large organised body; but, by the time the advance of the main army will take place, it is not doubted the exertions of the sappers to clear the way will have been attended with the required degree of success. After a reconnaissance of the Koomayloo course to within five miles of Senafe (which is distant 60 miles from Zoula), that route has been ascertained to be far more practicable than had been supposed, and the difficulties will be smoothed to such an extent that guns on wheels will be able to pass that way with tolerable ease. Directions have been given for a good road being made to the outlet of the mountain gorge on the other side, and hitherto the efforts made with that object have been attended with remarkable success. Near Senafe, it is believed, a capital sanitarium could be secured, 6000 ft. above sea level, possessing not only a cool mountain climate, but all the blessings of good perennial water, and only requiring the construction of a good suitable road, from fifteen to twenty miles in length, to render it easily accessible.

One doubt appears to have been already dispelled, and Indian silver passes current with the natives quite as readily as Maria Theresa dollars. Anything with the true silver ring would probably now go down among these matted-haired barbarians.

PARIS, LYONS, AND MEDITERRANEAN RAILWAY.—The increase in the traffic of this great railway this year, as compared with 1866, will exceed 650,000^l, the system having profited materially from the exceptional movement to the Paris Exhibition. After applying an extra amount to provide for the depreciation of way and plant, the dividend for 1867 is expected to be at the rate of 13 per cent. per annum.

BOILER EXPLOSION AT MANCHESTER.—A boiler explosion, attended with the loss of six lives, took place on Monday afternoon at Manchester. The explosion is attributed to the corrosion of the steel plates where they were in contact with the mid-feather on which the boiler rested. The explosion would probably have been avoided had the boiler been periodically inspected by a competent engineer. The premises on which the explosion occurred, those of Messrs. Chapman and Holland, dyers and finishers, Bromley-street, Ashley-lane, were very much damaged.

THE SOCIETY OF ENGINEERS.

THE annual dinner of the Society of Engineers took place on Friday evening last, at the Bridge House Hotel, London-bridge. The retiring president (Mr. W. H. Le Fèvre) occupied the chair, the two vice-presidents being respectively taken by Mr. Baldwin Latham (the president-elect) and Mr. Alfred Williams (the honorary secretary). After the usual loyal and patriotic toasts had been proposed and duly honoured, the toast of the evening, "The Prosperity of the Society," was given from the chair. The chairman, in proposing this toast, reverted to the early days of the Society, and traced its steady progress down to the present time.

The toast was responded to by Mr. A. Williams, the honorary secretary, who reviewed, for the twelfth time, the satisfactory progress made by the society during the past year, both with regard to the increase of members and to its finances. Starting from 1854, Mr. Williams observed that the society then numbered sixteen members. On January 1 of the present year, 1867, the total was 340. The additions during the year had been 65 members, 48 associates, 7 foreign members, and 12 honorary members. This addition had been slightly diminished by deaths, &c., to 123, and the present strength of the society was therefore 463. The state of the finances was equally satisfactory. The income for this year to the present time had been 781^l received, 546^l expended; 93^l had been added to the permanent fund, and the money of the society in hand was 191^l; on deposit, 393^l. The honorary secretary alluded to the large arrears of subscriptions, stating that, if those due had been paid up, the sum in hand would have exceeded 600^l. They had applied for a Royal Charter during the past year, to enable them to sue for debts due, but they had failed to obtain one. It was, however, satisfactory to state that very recently an Act of Parliament had been discovered which gave them the powers they sought under the Royal Charter. Under this Act, which was one for affording facilities for the establishment of scientific institutions, they could both sue and be sued, and hold property, &c., which would greatly increase the prosperity of the society.

THE BUBULINA.

THE wreck of the Bubulina, up to Wednesday evening, was in about the same position as when we last described it. The after part of the ship being the lightest, as there is neither boilers nor machinery in it, is being raised first. One lift only has been taken, by which it has been moved only a few feet towards the Liverpool side, the lifting shackles having given way. It was attempted first to lift the wreck by chains fastened to the side lights by a toggle inside. The diver broke the side-lights from the outside, and passed the toggle through; but the hull at the side-lights was not strong enough for this purpose, and was torn out by the pull on the chains. Chains were then passed under the hull, the diver having to scrape away the sand at the end of the wreck to allow the chain to be dragged under. The chain is swept by the tug-boat Tartar, which is in attendance on the divers, and it requires all the power of the engines to drag the chain along the underside of the hull; for the great current in the Mersey is fast sanding up both portions of the wreck, and daily making the lifting more difficult. On Monday, while passing these chains under, the diver, Mr. Allen, one of the bravest in England, had a perilous adventure which illustrates very well the dangers of his calling. He was passing round the wreck to see that the chains were properly placed, when his air-pipe got foul of one of the chains. He attempted to return, but discovered that he had passed between the chain and the hull, and that his pipe had been taken in with the undergirding chain, which was now being hauled close to the hull, and both air-pipe and life-rope were fast, and the pipe almost collapsed. This was in six fathoms water. He, with his knife, cut the life-rope, freed it from the chain, and then tied the two pieces together. He then got the air-pipe in his hand, signalled to be taken up, and immediately cut the air-pipe and freed himself from the chain. On Wednesday afternoon two flats and two punts were in position across this portion of the wreck, with chains from each end of each, passing round the hull or fastened to the stern, and another flat had yet to be placed. It was the intention to make a trial that evening, about eleven o'clock. If the tackle stood, it was expected they could reach it in three tides.

Preparations are making to take out the engines from the forward part before lifting it. Altogether, the operations are found to be more difficult than was at first anticipated, as the wreck is not only bedding itself into the sand, but is being rapidly filled with sand, thus adding very much to its weight.

THE COTTON TRADE.—The average weekly deliveries of cotton from Liverpool to the trade this year have been 47,060 bales, as compared with 45,470 bales to the corresponding date of 1866, and 37,570 bales to the corresponding date of 1865. The average weekly consumption of the United Kingdom in 1866 was 46,850 bales, and in 1865, 39,130 bales.

SALTBURN-BY-THE-SEA.—Messrs. Cochrane, Groves, and Co., of the Ormesby Ironworks, have entered into a contract for the ironwork of a new pier about to be carried out at Saltburn-by-the-Sea. The price per ton in this contract is considerably lower than had been calculated upon by the engineer.

IRON IN FRANCE.—The total production of pig iron in France in 1867 is estimated at 1,142,800 tons (of the value of 4,806,800^l), as compared with 1,253,100 tons in 1866, showing a decline this year of 110,300 tons. The total production of iron in France in 1867 is estimated at 801,000 tons (of the value of 7,393,800^l), as compared with 811,900 tons in 1866, showing a decline this year of 10,900 tons.

SOUTH YORKSHIRE.—There has been rather a better demand for Bessemer steel, principally rails and tyres, in South Yorkshire. A moderate business is being done, principally as regards engine fuel, into Lancashire by the Manchester, Sheffield, and Lincolnshire Railway. No alteration is noted in the demand for coke.

SHEFFIELD.—There is some improvement in the state of business at Sheffield. A good deal is doing in most descriptions of railway material. The iron trade, however, is dull; it is expected that the men will consent to a reduction of wages, of which notice has been given.

MR. ROBERT NAPIER, ENGINEER AND SHIPBUILDER.

ROBERT NAPIER was born on the 18th of June, 1791, in the town of Dumbarton, which stands at the mouth of the Leven, a tributary of the Clyde, some sixteen miles west of Glasgow. His native town is of great antiquity, but it is more important for us to note that, although Glasgow now far surpasses it in the extent to its shipbuilding and marine engineering, the time was when Dumbarton was a much more important ship-building town than its "big neighbour;" and yet, in the person of its Dennys and McMillans, it still occupies a proud position. Robert Napier's ancestors had long been identified with the town and county of Dumbarton, and his immediate progenitor was a well-known freeman of the town, and a blacksmith. It is to this circumstance that Mr. Napier refers when he playfully remarks, as is his wont, that he was "born with the hammer in his hand." Contrary to his father's wish, he betook himself, when about fourteen years of age, to the smithy, rather than to the university. This desire on the part of Scottish parents to give their sons the benefit of a complete course of university study and training frequently crops out in studying the Scottish character. Though he could not be prevailed upon to go to college, yet young Napier was well educated, so far as that was possible from attendance at an ordinary parish or burgh school. He was well grounded in classics and mathematics by his schoolmaster, and he gained much benefit from his intercourse with Mr. Trail, a gentleman who taught him drawing, both mechanical and architectural. Doubtless, the taste for the fine arts, which ultimately became such a passion in Mr. Napier's adult life, had its foundation laid in youth, during his intercourse with the gentleman just named, who was reputed a man of very fine tastes. He became apprenticed to his father, and, in following the trade of a smith, his example was followed by three of his brothers. Another brother, Peter, availed himself of the opportunity of acquiring a college education, by joining and passing through the arts and divinity classes in Glasgow University, with the intention of qualifying himself for "waggin' his head in a pulpit," which seems to be the great ambition in Scottish matrons in the humbler ranks of society. He became the Rev. Dr. Peter Napier, was ultimately appointed to the charge of the College parish church, and died in that charge some two or three years ago.

As a journeyman blacksmith and millwright of more than average abilities, Robert Napier remained in his father's employment, and gained a good deal of experience amongst the machinery of several cotton-printing and other large establishments for which his father worked. Being anxious to see about him a bit, and learn how work was then done elsewhere, he made up his mind, when he was twenty years of age, to seek employment in Edinburgh. His father's permission was obtained, and this was supplemented by an allowance of five pounds to secure himself against want until he got a place. He also fortified himself with a certificate of character from the minister of the parish. In Edinburgh he was successful in securing a place after the lapse of a week or two, and remained in it for nearly a year, receiving the very modest wage of 10s. 6d. per week. Although arrived at man's estate, he managed to live on that very small income; but as soon as possible he found another situation, in which his employer was none other than Robert Stevenson, the eminent lighthouse engineer, and builder of the famous Bell Rock Lighthouse, off the mouth of the Tay. In his new situation he got both better wages and better work. In course of time he left Edinburgh, returned to Dumbarton, and again entered the service of his father for a short while, shortly afterwards, however, becoming employed with Mr. William Lang, in Glasgow, whose chief business was the making of manufacturing machinery.

In the month of May, 1815, when he was consequently about twenty-four years of age, Mr. Napier determined to commence business on his own account. From his father he obtained the sum of 50*l.* in order to purchase the tools employed in, and goodwill of, a small blacksmith business in Greyfriars' Wynd, Glasgow. He had 5*l.* left after completing the purchase, and this amount formed all the circulating capital which he possessed for commencing business. At first his orders were so few that they could easily be overtaken by himself with the assistance of two apprentices whom he engaged. His first attempt in business was frequently a struggle and trial against difficulties. At length, however, business success began to show itself, and gradually he acquired such an amount of confidence that he had a sign painted at the corner of the wynd, and on it this inscription:

"Robert Napier, Engineer and Blacksmith."

Two of our friends, well-known engineers in Glasgow, inform us that they well remember the sign remaining on the wall long after Mr. Napier's business had been removed to another part of the town. The sign, in the lapse of years, became almost a classic sight in the town, among the engineers and their friends from a distance, and many pilgrimages were, from time to time, made to the spot. One of our Glasgow correspondents—Mr. Napier's senior by a year and a half—informs us that when last he went to look for the sign, some few years ago, it had disappeared.

Mr. Napier's engineering business in his first establishment consisted chiefly in the making of Bramah presses, and in doing a little millwright work, such as the making of mill-wheels. He used always to take to the making of these when trade was dull, remarking that they would be sure to be in demand soon. His second place of business was at the east end of Gallowgate, in what was called Camlachie Foundry. In it he devoted himself largely to ironfounding, the casting of water-pipes of large size being a sort of *specialité* with him. One of his principal contracts while in this foundry was for the large pipes required by the Glasgow Water Company when the supply was obtained from the Clyde, some few miles above the city. The Camlachie Foundry was obtained from his cousin, David Napier, and it is said that one condition of the bargain was that he should not build any marine engines. There are always two persons at least at bargain-making, and as one or both failed to implement the bargain mutually made, Mr. Napier took a contract to construct the engines for the Leven, which were till very lately

in active service. They now lie in Mr. Napier's engine-yard. The first land engine, however, which Mr. Napier made is still in use in Mr. Boak's spinning-factory in Dundee. From the Camlachie Foundry he removed to the historically famous Vulcan Foundry, in Washington-street, close to the harbour, and by-and-by he succeeded his cousin David in the occupancy of the adjacent Lanecfield Foundry, the site of the present enormous engineering establishment so well-known to many of our readers who have visited Glasgow, and inspected the engineering workshops of that busy hive of industry. Although he had dubbed himself an engineer, it was not until the year 1823 that Mr. Napier built his first marine engine.

The manufacture of marine engines had been going on for several years previously in Glasgow, in response to the demands of the new art of steam navigation. Glasgow had given birth to the steam-engine of James Watt; and the Clyde had, in the case of Henry Bell's little steamship, the Comet, so far back as the year 1812, effected a practical realisation of the idea of steam navigation so anxiously worked at by Miller, Taylor, and Symington, at Dalswinton Loch, and elsewhere; and, consequently, public attention was directed to the Clyde from all parts of the civilised world. The story of steam navigation is by far too long for us to dilate upon it to any extent in the present short sketch; it is also profoundly interesting and attractive; but we must not be tempted to say anything more about it just now than is actually requisite.

As already mentioned, Mr. Robert Napier succeeded his distinguished cousin in the works in Washington-street, Glasgow, and soon took possession also of what is now the Lanecfield establishment on Anderston Quay, when he began the profession of marine engineering in earnest, and on a much larger scale than had hitherto been attempted in any other place. While still in the Camlachie Works, in 1821, Mr. Napier was so fortunate as to secure the services of Mr. Daniel Elder as his manager, and it was partly in consequence that, in the following year, he felt induced to contract for the construction of the marine engine already alluded to as his first—that for the Leven, which, in 1823, was launched to ply between Glasgow and Dumbarton. That gentleman was an engineer of the first order for his power of effecting improvements in machinery and originating many others. In the engine with which the Leven was supplied, he introduced improvements in the air-pump, the condenser, and the slide-valve. The Eclipse was engaged by Mr. Napier in 1826, and employed on the Glasgow and Belfast route: Mr. Elder designed the engines of this vessel. His connexion with Mr. Robert Napier was a happy one for himself, and a fortunate one for Mr. Napier and his family.

The formation of the City of Glasgow Steam Packet Company, for the purpose of running first-class vessels between Glasgow and Liverpool, was an event of some considerable importance. That company was joined by Mr. Napier in the year 1830. Another company was formed about the same time, called the Liverpool Company, in which the Messrs. Burns were chiefly or largely interested. For both of these companies vessels of a very superior class were built, the builders being respectively Mr. Wood, of Port-Glasgow, and Mr. Steele, of Greenock, while the engine-builders were respectively Mr. Robert Napier and Messrs. Caird, of Greenock. The skill employed on these ships was very great, so great, indeed, that the voyages of the vessels were performed with great rapidity and regularity. They likewise caused much public excitement, for they would leave port at the same time, and would frequently arrive in the in-port almost "neck and neck." The Vulcan, John Wood, City of Glasgow, and Admiral are vessels for which Mr. Napier supplied the engines. Mr. Napier took much interest in the Dundee and London Shipping Company, and supplied to that company, in the year 1834, and subsequently, several first-rate ships of 250 horse power, including the Perth and Dundee, Mr. John Wood executing the shipbuilding, and Mr. Napier the engineering. Those vessels remained for a long time patterns of skill in naval architecture and marine engineering, and afforded a strong contrast to the other steamships frequenting the London Docks. Mr. George Duncan, formerly M.P. for Dundee, was the head of the company, and between him and Mr. Napier there long remained a close and intimate friendship. Mr. Napier engaged and supplied the East India Company with the Berenice, 220 horse power, in the year 1836, and subsequently with the Zenobia, 280 horse power, both of which were used as war and packet ships by the company. It was in the Berenice that Mr. David Elder was the first to apply expansion valves to steamers; at all events, that is the opinion of Mr. James R. Napier. In 1839, the British Queen followed with engines of 420 horse power, which were then considered of extraordinary size. Several finely modelled steam-yachts were also supplied about this time to the orders of the great turf celebrity, the late Mr. Asheton Smith. Amongst these we may mention the Fire King, 230 horse power, a vessel which was the first illustration of the hollow-line system, and which proved itself to be the fastest steamer then afloat.

In the year 1840 the Government was induced to enter into a contract with Mr. Napier to supply engines for two new war vessels, the Vesuvius and Stromboli, and, in this contract, as in all others, he made his most strenuous efforts to satisfy his employers to the utmost degree. When the return for the cost of repairs, &c., of a number of war ships—including the Vesuvius and Stromboli—was ordered by the House of Commons in the year 1843, it was found that the work executed by Mr. Napier stood the test most favourably when compared with that done by some other engineers, and consequently proved economical to the nation.

The origin of the British and North American Mail Company, or, in other words, the Cunard Company, in the year 1840, was an event of immense national and international importance. Glasgow has the honour of originating that company, Mr. Napier and Mr. (now Sir) Samuel Cunard, together with a number of eminent and wealthy Glasgow citizens, were the parties who resolved themselves into the company in question. It is an interesting story, a good deal of which we could ourselves unfold; but this is not the time, even if we had the requisite room. It will suffice if we mention that the money was found, and four ships of great size and power were ordered of

Mr. Napier—the Britannia, Acadia, Caledonia, and Columbia, built respectively by Messrs. Robert Duncan, John Wood, Charles Wood, and Steele, and all supplied with engines of 400 horse power by Mr. Napier. Thereafter he furnished the machinery for other vessels belonging to this company, such as the Hibernia, Cambria, America, Niagara, Europa, Canada, Arabia, &c. Some of these vessels have only been recently withdrawn from active service, being superseded by Mr. Napier's more recent and well-known vessels, Persia, 3600 tons and 850 horse power, Scotia, 4000 tons, and 1000 horse power, China, 2540 tons and 550 horse power, &c.

Among the more recent specimens of Mr. Napier's mercantile ships, we may mention the Pereire and Ville de Paris, 3300 tons and 800 horse power, belonging to the French Compagnie Générale Transatlantique, and a drawing of the engines of which we (ENGINEERING) lately gave in these pages. Mr. Napier's firm also constructed the Malabar, 4174 tons and 700 horse power (one of the five Indian troop-ships recently constructed), and which vessel, we believe, has given much satisfaction since her entrance on service last year.

Mr. Napier, further, has been very successful in the construction of machines and war vessels for the British, French, Turkish-Russian, and Danish navies; and when it was decided to reconstruct the British navy with armour-clad vessels, Mr. Napier's firm had the honour of furnishing one of the two armour-clad vessels first built, viz., the Black Prince, 6040 tons. Since then they have also built the Hector, 4062 tons and 800 horse power, and have at present on hands the Audacious and Invincible, armour-clad frigates, also for the British Government, each 3775 tons and 800 horse power, as well as two armour-clad turret vessels for the Dutch Government of large size.

Mr. Robert Napier was a juror of the Paris Exhibition of 1855, when he received the gold medal of honour, and the decoration of Knight of the Legion of Honour; he was chairman of the jury for Class 12 (Naval Architecture, &c.) of the International Exhibition 1862, and Royal Commissioner of the Paris Exhibition 1867, and then received a grand prize. He was one of the committee for the organisation of the Fine Art Exhibition in the South Kensington Museum in 1862, during the Great Exhibition. His great collection of pictures and articles of *vertu* at his palace at West Shandon is a sufficient guarantee of his for the honour then conferred upon him. In the summer of 1864, Mr. Napier presided at the Glasgow meeting of the Institution of Mechanical Engineers; his hospitality on that occasion will long be remembered by many of the members of the profession who were present at the meeting. He is also a member of the Institution of Civil Engineers.

In the year 1816 Mr. Napier married his cousin, a sister of the aforesaid David Napier, but now deceased. The issue of the marriage includes one daughter, the widow of the late Mr. Rigby, of the Parkhead Forge, and two sons, James Robert Napier, F.R.S., and John Napier. The last-mentioned gentleman still remains in the firm of Robert Napier and Sons; his brother left, and commenced business, as a marine engineer and ship-builder, on his own account, in the year 1857.

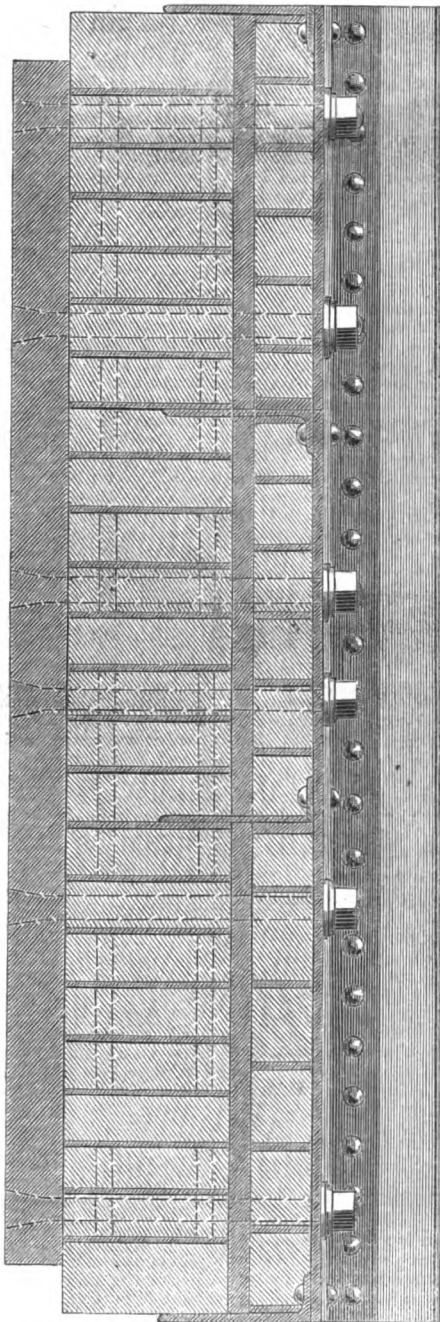
THE LATE M. GANZ.—The Austrian correspondent of the *Times* writes as follows respecting the late M. Ganz, the Hungarian ironmaster: "I cannot finish my letter without mentioning the death of a man which occurred before I left Pesth, and which will be felt all over Hungary as a national loss. It is that of the ironmaster Ganz, whose name as a manufacturer of railway wagon wheels is known all over the Continent. He was one of the few instances of a self-made industrial man in Hungary. He belonged to the south of Hungary, where he began life as a common workman in brass and iron. In company with a fellow-workman, who is said to have been the real inventor of the process of hardening cast iron, so that it resists wear and tear better than any other metallic composition, Ganz came up to Pesth, set up for himself, and by degrees enlarged his factory so as to give employment to several hundred workmen, and was scarcely able to supply the orders for his solid railway wagon-wheels. Not three weeks ago he gave a *fête* to his workmen in commemoration of the hundred thousandth wheel which came out of his works. He had just risen from a typhus fever, and the difficulty which he had in getting the iron, owing to the want of means of communication, seems to have been preying on his mind. He was dining on Sunday with his family, got up in the midst of dinner, and ran to the top of the stairs, followed by his wife, who, however, came too late to prevent his throwing himself down from the top of the third floor. His funeral on Tuesday was quite a public ceremony, for his loss is felt to be a national one. That the loss of a man who would not be unworthy of a biographer like Smiles should be felt in Hungary as a calamity speaks more than anything else could of the change which has come over that country."

THE FOREIGN COAL AND IRON TRADES.—We have to note the delivery of some English tenders in a competition for *matériel* required by the Belgian State railways. For two lots, each comprising 300 wheels for carriages and trucks, M.M. Nicaise and Delcuve, of La Louvière, tendered at 173*l.* each lot; while Charles Cammell and Co. (Limited), of Sheffield, tendered at 185*l.* each lot; several other tenders were also delivered at intermediate rates. It appears that the price at which the Creusot Works are about to supply 80 locomotives to the Orel and Witbebsk Railway (Russia) is 2512*l.* per locomotive, delivered at Riga; the Creusot Company undertakes to accept obligations guaranteed by the Russian Government to the aggregate sum represented by their contract, but at the same time the 80 locomotives and tenders to be delivered at Riga are to be paid for in cash. A contract for 25,000 tons of rails is expected to be given out shortly for the Poti and Tiflis Railway, another Russian line recently conceded. The low terms at which the house of De Dordodot recently took a contract for rails for the Belgian State railways has been a good deal discussed. The Decazeville mines and ironworks in the French department of the Aveyron have been disposed of to the Orleans Railway Company for 115,200*l.*

THE CHALMERS TARGET.

TO THE EDITOR OF ENGINEERING.

SIR,—I send you a sketch of the target alluded to in the accompanying extract from my paper on "The Armour Plating of Ships of War." I shall be glad if you think it worthy of a place in your columns. I was prepared (with the assistance of some friends, who were actuated by patriotic



motives as well as a desire to aid me) to risk over a thousand pounds on its success. The following were the terms proposed to the Admiralty:

"I shall consent to accept the risk of such a trial on the condition that, if the Rodman gun at 70 yards, with 100 lb. of powder, does not penetrate the target, the system of backing which I have so long advocated shall be adopted in Her Majesty's ships. As to compensation or reward, or even the cost of the experiments, I shall be content to leave myself in the hands of the Government."

Though this offer has been for the present rejected, I do not despair of its ultimate acceptance. The force of public opinion may yet induce the Board of Admiralty and their advisers to build our ironclad ships as strong as iron and steel can make them, when a compound backing will be absolutely necessary.

I am, Sir, your obedient Servant,

JAMES CHALMERS.

London, December 23, 1867.

Extract from Mr. Chalmers's Paper.

"Improvements in ordnance are now being developed in two distinct and essentially different directions. In Europe they tend towards rifled guns and elongated projectiles possessing great range and great penetrating power. In America the crushing energy of massive round shot is chiefly depended on. The characteristics of our system are of the scimitar or lancet nature, sharp and subtle, while those of the American system remind us of the battle-axe or two-handed sword of former days. The respective values of these two systems of ordnance have been forcibly illustrated during the past summer in the experiments against the 8 in. Warrior target. The results of these trials are too well known to need recapitulation here, but the difference in the nature of the damage effected by the two systems of attack has not, to

my knowledge, been very much dwelt upon. The fifty or sixty rounds from the Woolwich guns made as many indentations or small holes in the target, some of them through, but not impossible or even difficult to plug up. Indeed it is a peculiar feature of the hole made by the Palliser shot that it will always be easily stopped. The ogival head of this shot in entering an iron plate invariably raises around the hole a fringe of metal which curls outwards, forming just such an opening as a mechanic with a boring tool might be expected to make if he desired to facilitate the entrance of a plug. The holes are generally of the same size, so that an enemy will always be able to keep a stock of plugs of the exact size on hand. The fringe around the hole would also form a rest or support for the feet of any one who, with mallet and plug, went over the side to stop the hole. The round shot of the 15 in. Rodman, on the other hand, made a ragged hole which nothing in the nature of a plug could stop—a hole through which we could hand a chair or push an ordinary wheelbarrow. In plain English, one shot from this gun did more real damage to the target than fifty rounds from our own guns had done. It was not penetration merely, like that of the Palliser shot, which, when it does penetrate, comes slipping through the target without carrying anything before it—the Rodman shot converted upwards of a ton weight of the plate, backing, skin, frame, and bolts into thousands of fragments, scattering them far and wide in rear of the target, like chaff before the wind, or the debris of some terrific explosion. One feature more should not be forgotten: the ricochet at sea of a rifled shot (such as the Palliser) goes for little or nothing—it can never be depended upon. This, and nothing else, decided the fate of the Alabama. The Kearsage fought with smooth-bores, and the Alabama with rifled guns; we know the result. Besides the uncertainty of rifled guns in a sea-fight (at such ranges as the shot in its flight may touch a wave), there is the important fact that the small bores of these guns leave no margin of power in cases of emergency. A 9 in. gun, for instance, will burn 43 lb. of powder; but, though it could stand 60 lb. without bursting, and some emergency demanded more power, the gun could not burn the powder. The 15 in. Rodman, on the other hand, the battering charge of which is 60 lb., has often been fired with 100 lb. charges, all of which appears to have been burnt in the gun, judging by the velocity of the shot and its effects. There can be little doubt that the commander of a ship carrying such guns would risk even heavier charges rather than go to the bottom or lose his ship. One thing, at least, is certain, if we take the experiments of last summer as data, and that is that no British ship, now afloat, could, without risking certain destruction, approach within 800 yards of any vessel or fort armed with 15 in. smooth-bore guns capable of standing 100 lb. charges. The 8 in. Warrior target was much stronger than the side of any ship in the British Navy. It has 26½ in. depth of structure, 8½ in. of which was iron, not counting the frame, while the Hercules, even, has only 19½ in. depth of structure at her batteries, of which not more than 7½ in. is iron. When Sir Alexander Milne came to the Admiralty, I called his attention to the effect which the large American smooth-bores would have on thin-sided ships of the Minotaur or Bellerophon class; but he seemed to underrate the power of these guns as much as he overrated the strength of our ships. An undue contempt for a probable foe and an over-weening confidence in ourselves are dangerous qualifications in one who may virtually be considered our naval commander-in-chief. It is but just, however, to say that the power of these guns was not so well known then as it is now. I am of opinion that the 15 in. Rodman gun, with 100 lb. of L. G. rifle powder, would send a steel shot through both the Minotaur and Bellerophon targets, if placed the one behind the other, a few yards apart, and that there would be enough remaining work in the shot to seriously damage a third target. I am also of opinion that the same weight of iron as used in the 8 in. Warrior target, or the Hercules, if arranged on the system adopted in the Chalmers target, with steel plates in the backing, would resist the 15 in. gun with 100 lb. charges, and I have offered to back this opinion by consenting to accept the risk and stand the cost of the trial. But this offer the Admiralty declined, probably because their lordships still held to the Controller's dictum, that 'the relative resistance to shot of the several targets has no bearing on the question.' Let us hope that the official views of this important question may undergo a change before we sink to the rank of a second or even a third-rate naval power. That such a contingency is probable is demonstrated by the fate of the 8 in. Warrior target. A strong sea-going turret-ship, carrying four 15 in. guns, could destroy any or all of our iron-clad ships as they severally came within 1000 yards. Such a ship, presenting herself a small target to our guns, could (unless she were destroyed, as it were, by accident) cruise up and down the Channel, and engage and destroy every ship in our navy *seriatim* without having to enter a port to repair. Armour plating has completely changed the conditions of success in naval warfare, and such a ship as here sketched may belong to some small nation that has no naval prestige, and few ships besides. If the danger alluded to be real, it is consoling to know that no nation has greater facilities for averting such danger, provided the management of our resources is in proper hands. There can be little doubt that our naval power now, as represented by our iron-clad navy, is neither so imposing nor real compared with that of other powers as it was twenty years ago, and one of the greatest drawbacks to improvement in this direction is the existence at the Admiralty of the absurd notion that relative resistance to shot is a consideration of little or no importance. In alluding to the vulnerability of the several classes of our iron-clad ships, I might have been more explicit in estimating the distance and circumstances under which they could be respectively penetrated by the 15 in. Rodman gun. The fact that this gun has proved itself to possess a great margin of power renders any nicety on this head uncalled for. The theoretical power of the American cannon was elaborately estimated in the able paper of Captain Noble, though Lord Elcho, in speaking of the 8 in. Warrior target, naively ob-

serves that the gun sent its shot through the target and the calculations at the same time. I might also have dwelt on the partial nature of the protection which we give to our ironclads, and with fairness have alluded to the great extent of unprotected surface above water as evidences of weakness. I might justly have argued that the strength of a ship of war, like that of a chain or a steam-boiler, is only equal to that of its weakest part, but I have preferred to deal with the best and not the worst features of our iron-clad ships. If I have said more about the American cannon than about our own guns, it is because our ships are more likely to encounter such ordnance, and because the great smooth-bore Rodman is the only foreign gun of any note that has been tested in this country against armour plates. Besides, we must not forget that this is a broad and vital question, not prospective merely, but affecting our national influence and policy *now*. Many of us remember the clever letters that appeared in the *Owl* some years back, purporting to be instructions from the Secretary of the Admiralty to the commander of the Channel fleet in relation to the Danish war. In these letters the unsatisfactory condition of the navy, and the consequent decline of our naval prestige, foreshadow and account for the failure of Earl Russell's Danish policy. I have greatly underrated the sagacity of American statesmen, especially Mr. Seward, if the destruction of our strongest target by the American gun last summer do not affect the negotiations now pending between the two countries. Whether it influenced the rejection of our offer of arbitration or not I cannot tell, but there can be little doubt that it is calculated to augment the difficulties of Lord Stanley's position in regard to the Alabama claims. Should some disaster more terrible and more tangible than the mere loss of prestige compel us to consider the state of our navy, its armaments, and its armour, it will afford us little consolation to learn, when too late, how easily it might have been prevented."

THE ANTI-INCURSTATOR.

TO THE EDITOR OF ENGINEERING.

SIR,—We are very much surprised to find a letter in your last impression, signed "Boiler," which casts a libel upon everybody connected with Baker's patent anti-incrustator.

We beg to say, in justice to ourselves, that his assertions are wholly inaccurate as far as our experience goes.

We have the licenseeship for almost the whole of this country, and we most positively assert that we fully believe in the efficiency of the anti-incrustator as at present constructed, and that all our sub-agents have equal faith in the invention, being empowered by us to guarantee its efficiency to our customers.

We cannot but think that the letter has escaped your observation, otherwise you would not have allowed its insertion, and thus permit an *anonymous* correspondent to characterise the invention as a "swindle," without at least giving his name and address, to enable the public and ourselves to test the truth or otherwise of his assertions. Will you please insert this letter in your next edition, and inform us in the mean time who your correspondent "Boiler" is?

Yours obediently,

Airedale Foundry, Leeds,

KITSON AND CO.

December 24, 1867.

[We cannot disclose the name and address of any correspondent to whose letter, written over a *nom de plume*, we may give insertion. But we doubt not that "Boiler" will not hesitate to come forward, with his evidence, over his real name.—ED. E.]

TO THE EDITOR OF ENGINEERING.

SIR,—I am considerably surprised at reading in your paper of the 20th instant a letter condemning the electrical anti-incrustator as a "swindle." The strong term used, however, has too much the appearance of *prejudice*, or a diversion in favour of some other so-called anti-incrustator, to need further comment. I may add that I have seen the most satisfactory results, even in case of old boilers, from its use, and think it only right publicity should be given thereto in the columns of your valuable paper, as I firmly believe that, where fixed strictly in accordance with the directions given by the manufacturers, there can be no doubt of its proving the most valuable anti-corrosive agent yet introduced. As regards the corrosion of the spikes, there is no difficulty in their being replaced should they become, after much use, ineffectual.

Yours truly,

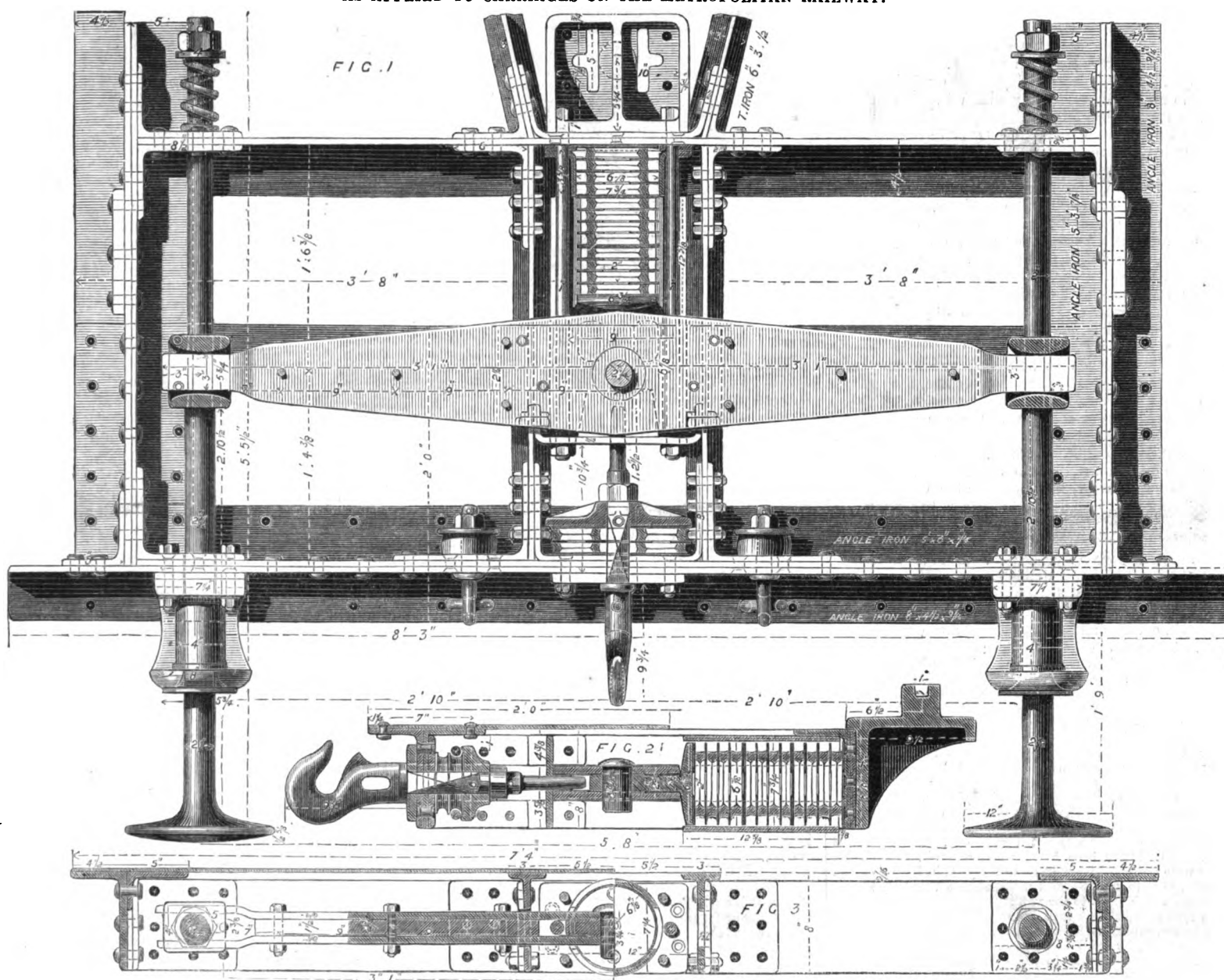
Fordingbridge, Salisbury.

VULCAN.

TUNNEL UNDER THE CHICAGO RIVER.—The tunnel under the Chicago River is again under way with every chance of a thorough and successful prosecution of the work. From Mr. Chesbrough, city engineer for Chicago, and originator (as all know) of the famous Lake Tunnel, as well as the plan for raising the entire city, which has been so successfully carried out under his management, we have received the specifications for the work, from which we learn that the bottom of the tunnel, or top of invert in the middle of the river, is to be 32.4 ft. below low water. The length of tunnel will be 838 ft., with open approaches of 770 ft. in all. The tunnel under the river is to consist of three passage-ways, one 10 ft. wide for foot-passengers, the others 11 ft. each, for vehicles.—*Journal of the Franklin Institute.*

RUSSIA.—The Russian Government is making great efforts to develop the mechanical industry of that empire. For instance, it is noted that the construction of a bridge proposed to be thrown across the Boug, on the Warsaw and Terespol Railway, for the construction of which tenders had been invited from a number of Russian and foreign establishments, has been let to a Russian house. The Russian Government also intends to order a quantity of plant—including locomotives and tenders—from four works on its territories. It is further hinted that the Russian Government is disposed, where necessary, to stimulate Russian mechanical industry by direct pecuniary advances.

STERNE'S PNEUMATIC BUFFER AND DRAW-SPRINGS, AS APPLIED TO CARRIAGES ON THE METROPOLITAN RAILWAY.



We give, above, engravings of Mr. Louis Sterne's pneumatic buffing and draw-springs, as they are now being applied to the carriages on the Metropolitan Railway. The resistance of Mr. Sterne's pneumatic springs is partly due to the action of the india-rubber rings of which they are composed, but principally to the air enclosed by these rings. Each spring consists of a number of india-rubber rings placed between brass plates, the terminal plates of each spring being complete discs, whilst the others have each a hole in the centre. During the process of vulcanisation, the rings become securely attached to the plates, and each spring becomes thus a perfectly air-tight case. When a pressure is brought upon the springs, the air within them becomes compressed, and offers a resistance proportionate to the amount of such compression and to the area of the discs upon which the pressure of the air is exerted. As we have said, the india-rubber rings themselves also, to some extent, assist in resisting the compressive force, but their main office is to retain the air within them. They are made of somewhat peculiar section, as will be seen by reference to the engravings.

In the case of the Metropolitan Railway carriages, each buffer-rod carries a kind of shoe, which embraces the corresponding end of a compensating beam, which extends from one spindle to the other. This beam is composed of a pair of $\frac{1}{2}$ in. plates, 10 in. broad in the centre, bolted together at a distance of $1\frac{1}{2}$ in. apart, with wooden packing pieces between them. At the centre a pin, $2\frac{1}{2}$ in. in diameter, passes through the beam and through an eye, forming part of a brass casting, which bears against the end of the buffing spring. The shape of this casting will be understood by reference to the figures, and from these it will be seen that its sides are fitted to a pair of 1 in. bolts on which it slides, the length of the bearing surfaces being $10\frac{1}{2}$ in. The casting thus forms a kind of crosshead, which carries the beam and transmits the pressure of the buffers fairly to the springs, and the beam itself enables the buffers to accommodate themselves to the positions assumed by the carriages in passing round curves.

The buffing spring itself is really composed of three of the pneumatic springs, each consisting of four india-rubber rings, with the necessary intermediate and terminal plates. The three springs occupy a length of 12 in., when uncompressed, and they

are capable of being compressed 9 in., the range being limited by the length of the slots in the sides of the wrought-iron case which surrounds the spring, and through which slots the arms of the crosshead work. The manner in which the spring and its case are secured in their places will be seen by reference to the longitudinal section and sectional plan; and these views also show the manner in which the transverse frames of the carriage are braced, so as to enable them to resist the central thrust of the buffing spring. It will be noticed also that the inner ends of the buffer-spindles are fitted with light spiral springs, which bear upon the inner transverse plate, through which the spindles pass, and keep the shoes always bearing against the ends of the beam, thus preventing "chattering." The buffer-spindles are $2\frac{1}{2}$ in. in diameter at the outer part of their length, and 2 in. in diameter within the shoes. The buffer-heads are forged on them.

The draw-spring is formed by a pair of the pneumatic springs placed one on each side of the drawbar, each spring consisting of two india-rubber rings, with the intermediate and terminal plates. The pressure is transferred to the spring by a cast-iron cross-plate as shown in the sectional plan.

Mr. Sterne's pneumatic springs have been most severely tested by Mr. Burnett, the locomotive superintendent of the Metropolitan Railway, and they have been found to withstand all the trials most satisfactorily. One of the trials consisted in placing one of the carriages, fitted with the buffers, with one end against a brick wall and running an engine against it, the steam being kept on after the engine and carriage came into contact. Even this severe treatment produced no failure of the springs. The pneumatic springs have also been used with successful results on the Great Western and other railways. Our engravings—which have been prepared from working tracings, with which we have been kindly supplied by Mr. Burnett—show the arrangement of buffers, which is now being applied to fifty new carriages on the Metropolitan Railway.

THE RICHARDS INDICATOR.—Messrs. Elliott Brothers have now sold upwards of one thousand of these admirable instruments, and the demand for them is continually increasing.

RAILWAY IRON IN CANADA.

CAPTAIN TYLER and Mr. C. W. Eborall's report upon the condition of the Grand Trunk Railway of Canada contains a most lamentable account of the failure of iron rails upon that line. That this failure has been exceptional and peculiar we have no reason to suppose; indeed, evidence might as easily be collected to show the premature destruction of iron rails upon many other lines; but it is only seldom that the severe truth of such failures is permitted to pass upon authority into print, and to thus go before the whole railway world—a planet, by the way, of no inconsiderable magnitude.

The Grand Trunk system has an extent of 1377 miles, or 45 miles more than the London and North-Western, the Grand Trunk being, however, a single line for the greater portion of its length. The traffic receipts of the Grand Trunk are not, however, one-fourth as great as those of the London and North-Western, and it is worked by, in all, 298 engines, where the latter has about 1400. The average daily mileage of the Grand Trunk engines for the last five years has been 68 miles, so that the equivalent number of thorough trains daily in both directions has been $\frac{298 \times 68}{1377} = 15$ nearly, or rather more than 7 each way.

Some portions of the line are, of course, worked much harder than others, and the trains drawn are heavier than those on English lines, the average of goods per train being 150 tons against only 58 in England, and the average number of passengers per train being 120 against 73 here.

It is, of course, only by considering the traffic that we can form any useful notion of the wear of rails, for

to say that a rail has worn five, ten, or twenty years means nothing unless we have some idea of the tonnage that has passed over it. Ordinarily from six to thirty million tons of traffic will completely wear out a line of iron rails, the quality of iron being always very variable, and it will be found that many of the rails in the line will have been worn out long before even twelve million tons has been reached. The tonnage which will destroy a rail may accrue within a few weeks, or a few years, or only within twenty or thirty years, entirely according to the amount of the traffic. The rail loses little or nothing by mere exposure to the weather, and the silent agency of time. If wagons, loaded to a gross weight of 10 tons, and measuring 20 ft. over the buffers, were passed *continuously* over a line, at the rate of 20 miles an hour, the tonnage would exceed one and a quarter millions every day, and the rail would be worn out in from four to twenty four days, according to its quality. With but one-seventh as much traffic, the rail would last as many weeks; with but one-thirtieth as much traffic, it would last as many months, and with but $\frac{1}{125}$ th as much traffic, it would last, practically, for as many years.

If the average gross weight of the Grand Trunk trains were as much as 250 tons, and fifteen such trains were run daily over a single line, the wear of rails would be at the rate of 3750 tons of traffic daily, and even if the rails could bear but five million tons they should last 1333 days, or 3 years 8 months, nearly. Their durability ought, of course, to be much greater, since the best iron rails ought to withstand five or six times as much wear, in which case the Grand Trunk rails should have lasted from eighteen to twenty-two years. Here and there, indeed, Captain Tyler reports that rails nearly or quite twenty years old are still down in some portions of the line. But the experience with the great bulk of the rails has been very different. The report shows that from the beginning of 1860 to the 14th September last, 738 miles of line had been renewed, corresponding to an annual rate of 98 miles a year. The report goes on to say:

These renewals have been made principally with T Vignoles rails re-rolled at or supplied from the following places: 55,000 tons re-rolled from time to time at the Toronto rolling-mill; about 8000 tons re-rolled at the Bay State mills, near Boston; about 8000 tons re-rolled at the Worcester mills; 5000 tons supplied from England by the Ebbw Vale Company in 1862, and 2000 tons in 1864; 900 tons supplied by the Rhymney Company in 1864. There have been also some rails re-rolled latterly at Portland.

Of the Toronto rails 124 per cent. have been again renewed, and the average life of these rails up to the end of 1866 may be estimated at less than eight years. They were at first too light, and the section was not a good one. The later rails from that mill have been heavier and of an improved form. They were increased from 62 lb. to the yard in 1860, to 64 lb. in 1863, to 69 lb. in 1864, and it is desirable that they should in future weigh 75 lb. to the yard.

In 1865 puddled bars were imported from England with a view to improvement for the heads of these rails, but the heads so applied proved to be too soft, and it has since been found more advantageous to place the puddled bars between an upper layer of old bridge-rail iron, improved by a second rolling, and the lower bars of old iron which complete the pile. A head sufficiently hard has thus been combined with a rib and bottom flange of the requisite degree of toughness, and the puddled bar appears to have formed a good weld with the iron on either side of it.

The rails re-rolled at the Bay State and Worcester mills have in like manner proved to be too soft, and have more or less been crushed under the weights of the engine-wheels. Nearly the whole of the former iron, and about 20 per cent. of the latter iron, has already been again removed from the track, and the rails re-rolled at Portland have shown similar indications.

Of the rails which were sent out in 1862 by the Ebbw Vale Company, and were laid down in 1862-63, 60 per cent. have already been taken out of the track, a large proportion have been shortened or repaired, and few remain in the condition in which they were originally laid. Their average life is estimated at less than five years. Of those sent out by the same company in 1864, at an increased cost of 2l. per ton, and called "steel headed," the average life will not, it is considered, be longer than six or seven years.

The Rhymney Company's rails, laid down in 1864-5, have also worn badly, and will all be renewed again by the end of 1868.

The life of all these rails ought, if they had been of suitable quality and of reasonably good iron, to have averaged at least ten years. On this assumption, and taking into account the expense of removing, cutting, and repairing, the loss to the company from their defects may be estimated to have been *directly* in money value:

Toronto rails, loss on 55,000 tons ...	£80,000
Bay State and Worcester rails, loss on 16,000 tons ...	40,500
English rails, loss from 1860 on 7900 tons ...	24,000

Total direct loss in seven years ... £124,500

But the indirect loss has been far greater. About 200 miles of rails, which ought still to be in the track, having been removed from it prematurely, the officers of the company have found it impossible to renew other portions of the line where renewal was urgently required. The old Ω rails, employed

by the contractors during the construction of the railway, and for traffic ever since that time, have unavoidably been kept in use longer than their condition would otherwise justify. Fractures of these rails frequently occurred, and the results of these fractures and other defects, by causing accidents and obstructing traffic, with their attendant inconveniences and delays, enhanced the difficulties of the company to an enormous extent.

When the company was in financial difficulty some years since, the permanent way fell into a depreciated condition, as is too frequently the case under such circumstances. Much time and expense would then have been required in any case to raise it from that condition. But when it became necessary to renew the new rails in place of the old ones, the difficulties of the case were, as may be imagined, materially aggravated; and it has taxed the officers and servants in charge of the track to the utmost to keep the trains running. The rails have been turned end for end, cut, patched, and much worn down in the process. They have been changed from the branches to the main line, and from one part of the system to another; and those which had been once rejected from the main line and laid down in sidings were even in some cases restored for a further term of service to the main line. It is only right by mentioning these facts to show the difficulties with which the officers now in charge of the permanent way have had to contend. The fractures that occurred were chiefly in the Ω rails, of which 3204 miles remained in the track up to the end of 1866. They broke mostly, as might be expected, at a distance of 2 ft. or 3 ft. from the joint, but frequently in other parts, after being much weakened by wear and tear. These rails, originally 21 ft. long, now vary in length. It is hardly necessary to say that they must, where the traffic is heavy, be removed from the track as soon as possible, a process which is being carried out as fast as new iron can be obtained. The best of them may, however, with improvements as to joint fastenings, which I shall presently recommend, be left longer in the track on those parts, as, for instance, on the 250 miles east of Richmond, where they have been less worn, under a very light traffic, and with fewer trains.

Considering the disordered finances and moderate traffic of the Grand Trunk Railway, Captain Tyler recommends *iron* rails for renewals, but he does this only upon the supposition that a really *durable* iron rail may be obtained at an advanced price. Mr. Brydges, however, the managing director, who was in London last summer, and who has had the management of the line for a number of years, has strongly recommended the board of directors to substitute steel in place of iron, and there can be not the least doubt that the adoption of this material would save the company infinite expense in the end. It is far more likely, too, that Mr. Brydges's advice will be followed than that of Captain Tyler, the former being the most responsible officer of the line, while Captain Tyler has had no other opportunities than a hasty run over it on this (we believe) his first visit to America.

METROPOLITAN TRAMWAYS.

TO THE EDITOR OF ENGINEERING.

SIR,—It is a notorious fact that the widest of our streets are too narrow for the daily traffic, and we cannot afford space for tramways taking a 5-mile radius from the Mansion House. In fact, such a system would not work at all satisfactorily in that area, and I trust a member of the M. T. C. (limited) is now fully convinced that your correspondent "D. T." has pointed out that when roads are made of different metals, that ruts will form, and accidents occur. The tramway between Westminster-bridge and Kennington had a grooved rail flush with the road, and, in my observation, I noticed when new metal was laid on the road that the small stones got kicked into the groove, and that the crushing and pounding of the said metal was grating to the ear, and I have no doubt the road trustees would have soon given in a claim for damages. The obviously simple plan of directing the traffic over the bridge with the flange rail system had to be given up for more than one reason. Notwithstanding the police regulated the traffic when a string of vehicles were on the rail, an omnibus stopping or an occasional break-down brought the rest to a stand, and although a Hansom cab driver could overleap the flange, a four-wheeler could not, so had to back out or wait until the obstruction was removed. Now a smooth tramway of cast iron has advantages in a scientific point of view, as the vibration is less felt; but even it had to be taken up, as a smooth cast-iron surface affords no foothold for horses; consequently the tramways are open to the same objections, and although they have succeeded in other countries, I do not consider they are at all suited for the rapid driving in the metropolis; and the scheme has been twice tried, and been found wanting. "A Member" will not go into the points about the cab ranks, &c., but shunts it over to the select committees. Well, I will just tell them that they must take to the one, and give up the other, and that, I have no doubt, would please all the members connected with the unfortunate company. But I say, go on; the day may come when the lord mayor's show, with all its pomp and pageantry, may ride along the Strand in a limited tramway company's cars, but I think that day far distant.

A word in conclusion. ENGINEERING has made it very easy work for the select committee this session. Many a bubble project will not have a very patient first reading, nor, I reckon, a second one neither.

December 21, 1867.

OBSERVER.

THAMES VALLEY DRAINAGE.—We are requested to state that Mr. Russ is not a member, of the firm of Messrs. Lucas and Wilkinson.

NEW SOUTH WALES AND METROPOLITAN CARRIAGES.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Robert H. Burnett is a young man, apparently full of health and spirits. As he grows older, in conduct and discretion, as well as in engineering experience, he will probably come to the conclusion that there are certain things he would wish undone, and certain words unsaid, which neither build up nor establish facts. All men in the long run must be measured by their general characters, and no amount of sneering will add to, or take from, the weight of an argument. If any man in the engineering profession assumes more than he is entitled to, there are abundance of clear logical brains therein to reduce him to his exact value. An engineer follows his profession more or less with the object of obtaining money, whether as an inventor of improvements or as the resident engineer of a railway; and it is just possible that Mr. Burnett does not himself serve the Metropolitan gratuitously; and so long as he makes his duty or his conscience paramount to his pecuniary gain, he is, if competent, a useful member of society. I will now proceed, categorically, with my answer to the letter of Mr. Burnett in your number of December 20.

1. In the year 1839 I placed on record the first plan that I am aware of for enabling the leading and trailing wheels of engines and carriages to take lateral and radial movement on curved lines of rails, with provision for preventing their running with loose movement on straight lines; and from that time to this I have been agitating the question in various forms, of which one was the radial axle-box. That "railway authorities" have not been "my humble and tardy disciples" Mr. Burnett himself gives proof.

2. I do claim "some merit" for the introduction of the plan for controlling the radiation of the axles of the New South Wales and Metropolitan carriages; and it is clear that Mr. Burnett considered it necessary to guide the movement, and render it safe, or he would not have altered the non-radial plan on which they commenced. He says that the Bissell engines have all worked very satisfactorily, "never seizing;" but fearing that the points might rust up, if applied to carriages, he did not use the Bissell plan to them. If he had used it, he must have used also the "double inclined planes" to keep it steady, which is said to be one of the requirements of the Bissell truck, and, moreover, a strong central framing to the carriage to carry the load. If it was essential to apply the Bissell movement to the comparatively short wheel-base of the engine, *à fortiori* it was important that the carriages should have the same construction, and still more on the long carriages of the Metropolitan.

3. I do claim the merit of having put on record, prior to any alteration or contemplated alteration in the metropolitan carriages, the principle of using very long swinging spring-shackles to give free movement to the wheels and axles, and at the same time guiding those wheels and axles by radial frames attached to the axle-boxes, the office of the frames being simply guidance without carrying the load, and giving free action for the rise and fall of the side-bearing springs.

4. I do claim the merit of putting the improved system on the traced plan of the Metropolitan carriage which Mr. Burnett says he furnished to me "in charity, as he gives a penny to a beggar." The object was to convert this carriage from its lever abnormal movement to a radial movement true to the curves of the rails, and this with as little alteration or cost as possible. The carriage consisted of a pair of unguided bogies, one at each end, and the shackles were quite inadequate to any effective amount of radial movement. The end shackles, 5 in. long, were replaced (on the tracing) by shackles 18 in. long; the side frames, connecting the axle-boxes, were supplemented by a cross-bar carrying a quadrant frame pivotted to the upper frame over the inner axle, thus giving true guiding movement without the frame carrying any load save through the springs, the pivot rising and falling through the frame to provide for the spring action.

5. Mr. Burnett did not put this in practice. What he did was, after passing through the phase of tying radial axle-boxes to the end wheels, and finding that they did not give sufficient side movement, was to apply this same principle of loose shackles combined with radial guidance to a single pair of wheels at each end, simply taking a pair of wheels away at each end out of the radiation. He thereby leaves a very long rigid base to the four centre wheels, which is less favourable to true movement than the radiation of all eight wheels would be, and certainly is less favourable than the arrangement of the wheels in Mr. Fowler's office for the New South Wales carriages, wherein the centre wheels are kept closer together.

Apparently Mr. Burnett conceives that, by applying the principle to two wheels instead of to four, he has avoided those arrangements in which I have what he calls a "loving interest." Had he consulted the record, he would have found that both four wheels and two wheels were provided for, and that the same principle applies to both.

6. I never said or implied that Mr. Burnett consulted me. He was first introduced to me at the Society of Arts, and I did then and since, as I should do to any one, state my views and plans for his acceptance or refusal. Judging from his letter, he would appear to be so self-contained as to need no one's counsel, and I do not assume to judge or impugn his powers. He may be competent to invent and plan everything connected with railways; but, nevertheless, the fact remains that I did put on paper for him the plan of the four radial wheels combined with the swinging shackles, and he has varied it to two wheels, apparently in the belief that he has achieved something original, or something avoiding my claim.

7. If, by a new combination and system, a carriage so constructed that it could not run without great surplus friction and possible risk on curves of rails, be made to run without that friction and risk, and without destroying its steadiness on straight lines, I submit that such a change constitutes a good and valid claim to originality, and that even supposing Mr. Burnett to have arrived at it independently of my plans,

that fact would not invalidate my priority, unless he had preceded me in recording it or using it.

Getting off the rails, and especially on the thickly trained Metropolitan line, is so serious an evil, that it is a perfectly legitimate pursuit for an engineer to devise means of preventing it. Had the description of the carriages not found its way into your pages, I should not have troubled you with writing on the subject; but I had to rectify the description in order to defend my own claim, or let it go by default.

I am, Sir, yours faithfully,

W. BRIDGES ADAMS.

EDITORIAL EDUCATION.

TO THE EDITOR OF ENGINEERING.

SIR,—The short paragraph on the above subject, quoted from *Echoes from the Clubs* in your last number, is no doubt well placed just at this time, when the subject of technical education engages general attention, for, to be sure, a little algebra should form part of the education of the engineer, and as very few of them hail either from Cambridge or from Oxford, this may form an additional reason why attention should be called to the subject in the columns of your journal.

Although the equations of which the Cambridge man complains are rather of the nature of puzzles, and have little practical value beyond the discipline of the mind which they enforce, the remarks of your contemporary are quite to the point. In presenting his and your readers, however, with the solutions of those dreaded equations, he has allowed himself to be betrayed into a mistake, which I must beg leave to correct.

His solutions, or rather rendering of equations (1) and (3), are undoubtedly correct; but the one of equations (2) is faulty, as you will see from the following. Those equations read thus:

$$\sqrt{x^2-5} + \sqrt{y^2-11} = 7 \quad (2);$$

$$\text{and } x^2 y^2 - 11 x^2 - 5 y^2 = 45$$

and your contemporary reduces them into the following shape:

$$x+y=7,$$

$$\text{and } x^2 y^2 = 100.$$

Now, this latter evidently reduces itself into

$$xy=10,$$

and the only two numbers which fulfil the condition $x+y=7$ and $xy=10$, are 2 and 5, and to determine which of the quantities x or y should be made equal to 2, or 5, is merely a matter of trial by substituting these numerical values for the literal ones in the equations (2). Upon examination, however, you will observe that in no case will these values fulfil the conditions of the equations (2), for if you make $x=2$, then you get

$$\sqrt{x^2-5} = \sqrt{4-5} = \sqrt{-1},$$

which is an imaginary quantity, and

$$\sqrt{y^2-11} = \sqrt{25-11} = \sqrt{14},$$

which is not 7, but rather less than 7; and, on the other hand, $x^2 y^2 - 11 x^2 - 5 y^2 = 45 = 2^2 \times 5^2 - 11 \times 2^2 - 5 \times 5^2 = -60$, which, as you see, leads to the absurdity, $45 = -60$.

Similar results are arrived at by making $x=5$ and $y=2$.

Your contemporary, however, is not entirely wrong, for, by putting

$$\sqrt{x^2-5} = a, \text{ and } \sqrt{y^2-11} = b;$$

$$\text{then } a+b=7,$$

and $a^2 b^2 = (x^2-5)(y^2-11) = x^2 y^2 - 11 x^2 - 5 y^2 + 55$; but remembering that $x^2 y^2 - 11 x^2 - 5 y^2 = 45$, it follows that $a^2 b^2 = 45 + 55 = 100$, or $ab=10$.

If, now, you make $a=2$ and $b=5$, you get

$$\sqrt{x^2-5}=2, \text{ or } x^2-5=4, \text{ or } x^2=9, \text{ or } x=3,$$

$$\text{and } \sqrt{y^2-11}=5, \text{ or } y^2-11=25, \text{ or } y^2=36, \text{ and } y=6,$$

which, you perceive, is quite different from the solution given by your contemporary; but, upon investigation, you will find that these values fulfil the conditions of the equations (2), for $3^2 \times 6^2 - 11 \times 3^2 - 5 \times 6^2 = 324 - 99 - 180 = 45$.

You had better send a copy of your journal to your contemporary, that he may see his own error, and be a little less hard upon Cambridge men another time, notwithstanding their deficiencies. The fact is that these equations, though easy enough, require a great deal of practice in the manipulation of algebraic quantities to hit upon the *dodge* which will lead you into the proper track for their solution, and many a man, otherwise well up in mathematics, but not having had practice enough, might be found wanting if called upon to solve them. Thus equations (1) compel you to have recourse to logarithms, though not to the tables; equations (2) compel you to introduce two new unknown quantities; and equations (3) compel you to transform decimal into vulgar fractions, all which little dodges you do not think of, unless, by repeated practice, you know that you may require to have recourse to them.

I remain, dear Sir,

Yours very truly,

J. J. BIRCKEL.

December 23, 1867.

TO THE EDITOR OF ENGINEERING.

SIR,—If the *Echoes from the Clubs* were not quite so confident and censorious, it would perhaps be scarcely worth while to point out that, according to the second equation, $x=3$, and $y=6$; therefore $x+y=9$ (instead of 7), and $x^2 y^2 = 324$ (instead of 100).

I refer to that article in your journal of the 20th instant, which is headed "Editorial Education."

Newport, Mon., December 23, 1867.

C.

LOCOMOTIVE ENGINES.

TO THE EDITOR OF ENGINEERING.

SIR,—I have pursued with much diligence the gradual development of the Fairlie system of locomotive engine. Like many railway men and engineers, while acknowledging merit in new principles, and while following with interest the convincing arguments of a perseverant and far-seeing pioneer, I like to consult the teachings of practical experience as bearing directly upon the success or non-success of alleged improvements.

Mr. Fairlie, while claiming, and in my opinion very justly,

that his system is equally good for working level and straight lines, on the score of economy, maintenance, and renewals of permanent way and rolling stock, admits that his great object is to carry cheap railways (which, he says, not only open up new sources of industry and wealth, but carries a civilising influence wherever they extend, more patent than all else besides) into all parts of the globe. As a natural condition this necessitates the working of steep gradients and sharp curves; for without these cheap railways cannot be made to work both well and economically. Mr. Fairlie has set himself the task of designing a motive power that shall overcome these difficulties—no mean task, it will be admitted, —and I, for one, after a very careful study of the whole question, begun with grave doubts as to its success, am compelled to admit he has succeeded far beyond anything I could have conceived from his first introduction of the subject.

I have studied the problem of working steep gradients and sharp curves from an early date, being satisfied that, unless this could be accomplished, countries of extraordinary formation, like Switzerland, could never enjoy the full benefits of railway communication. The very interesting struggle, which took place in 1851, between some of our ablest engineers in designing the best locomotive engine for working the Semmering incline of the Vienna and Trieste Railway, arose in consequence of the Austrian Government offering a series of prizes to be competed for on this incline, showing at that early date how all-absorbing the subject was.

It will be remembered that four engines, the "Bavaria," "Neustadt," "Seraing," and "Vindobona," all of special design and from different makers, competed, and how the "Bavaria" came off victorious. It may not, however, be so well remembered that one of the competing engines, the "Seraing," sent by the Société Cockerill, of Seraing, was in form very similar to one of Mr. Fairlie's plans, viz., with a double-barrel boiler, central firebox, carried on a pair of steam bogies. This engine, I find, was fully described in your valuable publication, *vide* p. 84, vol. i., and it is concerning your concluding remarks—"we cannot say why this engine did not continue at work, but it failed to give satisfaction"—that I beg to state a few facts compiled from an authentic source. The fact of this failure, together with the apparent similitude between Mr. Fairlie's plans and the "Seraing," which any superficial observer would pronounce to be the same—as I did—prevented me for some time from closely examining the subject, but I was induced to do so by the articles and illustrations which appeared from time to time, not only in your journal, but in *The Engineer* also, and the unanimity with which both journals (being somewhat unusual) hold that Mr. Fairlie's principle was the right one and deserving the earnest attention of all railway men led me to examine more minutely the details of the two systems, and to decide, that while there is a close resemblance in outline there is as distinct a difference in the principle and the designing of the details as there is between the "Seraing" and an ordinary locomotive engine.

Moreover, the "Seraing," as is well known, failed principally for want of heating surface; had the engine been properly supplied in this respect, it would have given satisfaction, notwithstanding the very defective design of the details, especially of the machinery, which was so huddled together as to be entirely beyond the supervision and control of the driver. This is fully borne out by Herr Engerth, who, in his paper on the "Semmering Engines," says that had these defects not existed, the "Seraing" would have developed the best results.

So satisfied am I of the great superiority of Mr. Fairlie's system, that I have recommended its speedy adoption on our lines, and I trust ere long to see these engines at work. Their introduction will modify our notions of railway working very considerably.

I am, Sir, yours faithfully,

ADOLPH BRUNNER.

Winterthur, Switzerland, December 19, 1867.

A PROPOSED SUBWAY UNDER THE THAMES.

TO THE EDITOR OF ENGINEERING.

SIR,—If Mr. Doull had taken the trouble of making himself familiar with the subject treated on in his letter, he could hardly have failed coming across papers and pamphlets, by Mr. Barlow himself, the perusal of which would have instructed him, at least, enough to prevent his issuing such crudities as those brought forward in his communication. There is an old adage about somebody's grandmamma very applicable to the case. As most professional men are well aware, no engineer is more fully alive to the great theoretical superiority—and, within certain limits, practical advantages also—of a line with a descending gradient followed by an ascending one—in short, of an "undulating" railway, the mathematical principles of which were treated exhaustively at least thirty years ago.

The illustrations preceding Mr. Doull's letter also carry us back about the same number of years. The "patent fans" are precisely identical with the very crudest forms of rotary engines schemed in those verdant days. It is hardly necessary to criticise them under their new name, and in their new capacity of air-shovels. We all know how sweetly fans work when out of balance, as these are—*slightly*. Theoretically, neglecting friction and inertia, no power would be consumed in thrusting out and pulling back the blades. Practically, however, it may easily be shown that in a fan of the proportions shown in the sketch, working at a pillar of about 3 in. of water, the power absorbed by internal friction alone would be at least 50 per cent. of the whole. As the fan is, we are told, intended to work slowly, say, at only 200 revolutions per minute, it would not knock itself to pieces as soon as might at first be anticipated. At that speed the number of times motion would be changed in direction, or, in other words, the number of startings and stoppings of the blades would be merely some 80 times per second.

The other fan, the one like a policeman's rattle, I do not profess to understand.

Your obedient servant,

Westminster.

J. TUGWELL.

SEWAGE PUMPING-ENGINES.

IN May last, the Norwich Board of Health announced that they were prepared to receive tenders for the supply of pumping-engines for raising the sewage water of the city of Norwich, it being specified that the engines should be capable of raising 2500 gallons per minute through 18 in. pipes, 2600 yards in length, to a net height of 144 ft. above the bottom of the engine-well, and that they should also be fitted with low-lift pumps capable of raising 12,500 gallons per minute to a height of 20 ft. Each contractor was to supply his own design, and amongst those thus sent in was that of the late Mr. W. P. Wilkins, of Ipswich (who has been succeeded in business by his son, Mr. Thomas Wilkins), which we illustrate on pages 602 and 603. Ultimately Mr. Wilkins's design was not accepted, the Board deciding in favour of Messrs. Clayton, of Preston, who proposed to supply three beam-engines for doing the work. An engine of the same design as those proposed for use at Norwich was, however, erected by Mr. Wilkins in 1862 at the cement works of Mr. John Patrick, of Dovercourt, where it has been doing good duty ever since; and the present Mr. Wilkins has lately sent in tenders for the supply of an engine, of precisely the same kind, for pumping purposes at Worthing. In this latter instance there is a single engine driving one pump placed in a well 100 ft. deep.

As will be seen by the engravings on pages 602 and 603, the pumping machinery which it was proposed to use at Norwich was in duplicate, there being two similar engines, each provided with its own high-lift and low-lift pumps. The engines are of the inverted-cylinder or "steam-hammer" class, and they are placed on opposite sides of the engine-house with their crank-shafts in line with each other. The adjacent ends of the crank-shafts have coupling flanges forged on them, and by these they can be connected to an intermediate shaft, which thus couples the two engines when required. The high-lift and low-lift pumps of each engine are each driven from an independent countershaft, as shown in Figs. 1 and 2, page 602. The crank-shaft of each engine carries two spur pinions, which gear into spur wheels on the two countershafts, from which the high and low level pumps are respectively worked. The ratio of the gearing is 1 to 3. Of the pumps we shall give further particulars presently.

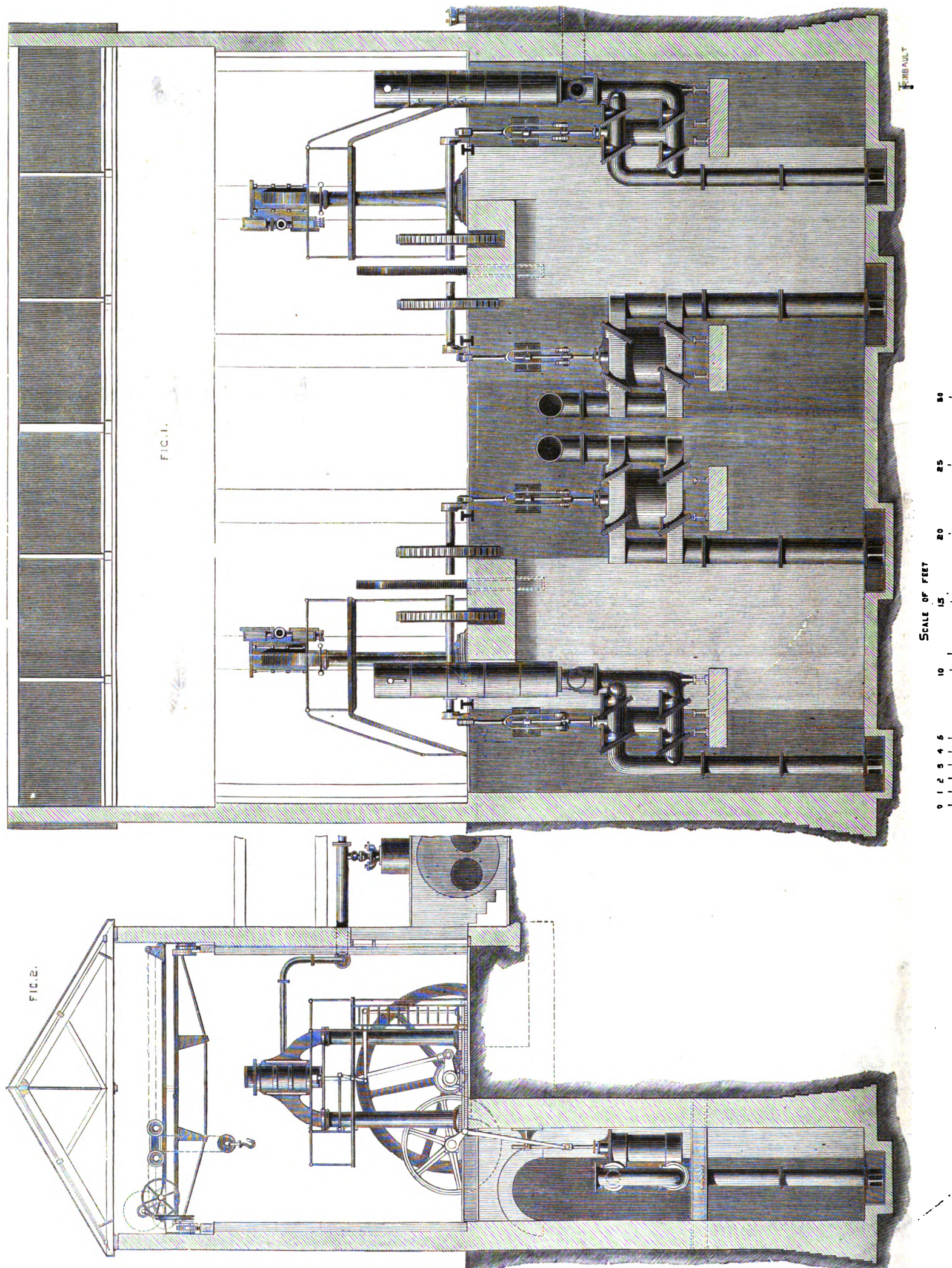
The construction of the engines will be seen from the enlarged views of one of them, Figs. 1 and 2, page 603. The cylinder, which is 2 ft. in diameter, with 3 ft. 6 in. stroke, is carried by a pair of castings which are bolted to it, and which rest upon a pair of cast-iron hollow columns, each 12 in. in diameter at the top and 14 in. in diameter at the bottom. One of these columns is used as a feed-water heater, the exhaust steam being led through it by a 5 in. cast-iron pipe, and the feed-water being caused to pass through the annular space between this pipe and the column. The lower part of the column just mentioned forms the condenser, and a cast-iron pipe leads from it to the air-pump, which is a single-acting pump of ordinary construction. The arrangement of feed-water heater should have been shown on the left-hand side only of Fig. 1. It will be seen by this section that the cylinder is not steam-jacketed; but that it is, on the contrary, exposed on one side to the influence of the exhaust steam on its way to the condenser—decidedly a defect in the design.

It will be noticed from the section, Fig. 1, that the engine has no guide bars, the piston-rod being guided by a parallel motion, a novel arrangement for engines of this class. One pair of radius bars of the parallel motion is made much stronger than the other pair, so that they form levers from which the air, feed, and cold-water pumps can be worked. This arrangement is a neat and convenient one. The distribution of steam to the cylinder is effected by a pair of short slide-valves with expansion-valves at the back, and a small valve, A, is provided, by means of which steam can be admitted by hand to either end of the cylinder, so as to facilitate the starting of the engine. The throttle-valve is of the equilibrium class, and is worked by a rod connected to a lever extending over the top of the valve-chest, as shown in the figures.

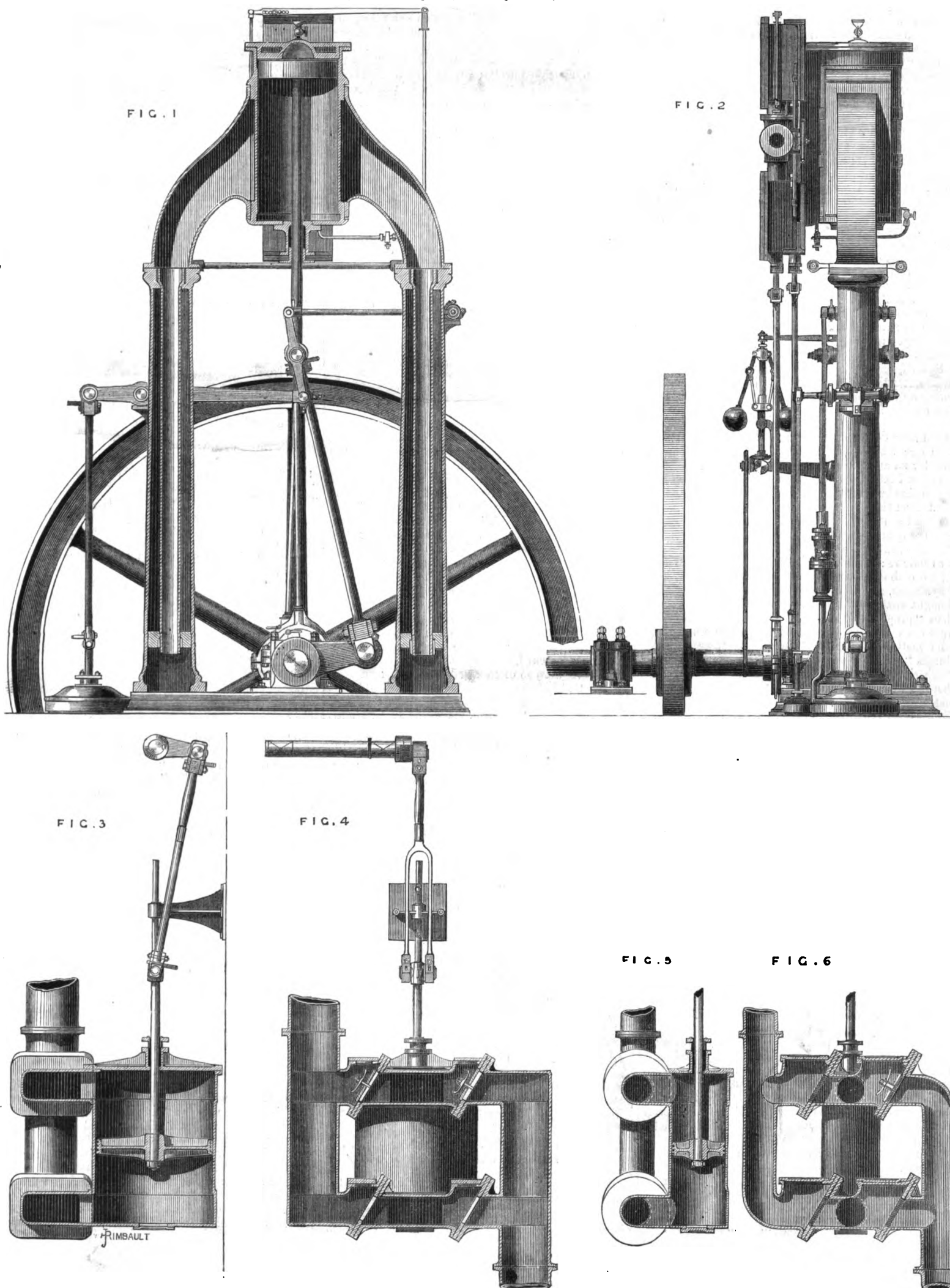
The construction of the pumps is shown by Figs. 2 to 6, Figs. 3 and 4 referring to the low-lift and Figs. 5 and 6 to the high-lift pumps. They are all double-acting pumps with 3 ft. stroke, the barrels of the low-lift pumps being 51 in. and those of the high-lift pumps 23 in. in diameter. All the valves are of india rubber, and they work on inclined faces situated in valve-chambers, which are connected to the pump-barrels by passages arranged as shown in the various figures just mentioned, from which it will be seen that the valves are readily accessible. The passages might have been arranged, however, so as to allow the water to follow a more direct course. The suction and delivery pipes of the low-lift pumps are 20 in., and those of the high-lift pumps 12 in. in diameter, and these diameters are not increased—as they might be advantageously—at the points where the valves are placed. The pumps are situated as shown in Figs. 1 and 2, the suction valves being about 18 ft. above the bottom of the pump-well, and they are shown in the drawings as being carried partly by the suction pipes, and partly by cast-iron girders which extend across the well. It would, however, have been better, we think, to have carried the pumps by the girders entirely, thus relieving the joints of the pipes from all strains caused by the action of the pumps. The delivery pipes from the low-lift pumps are united close to the pumps to a single main of larger diameter, and the same is the case with the high-lift; but in neither instance do the drawings show that any provision has been made for shutting off the pumps from the mains in the event of either of them failing. This is decidedly an omission, either in the drawings with which we have been supplied or in the design. It would also have been better, we think, if the pump-well had been divided into two parts, sluices being provided for excluding the water from either compartment at pleasure, so that one could be cleaned out whilst the other was being pumped from. The high-lift pumps are provided with large wrought-iron air-vessels on the delivery side, and a pair of safety-valves is also fitted to the rising main just outside the engine-house. The pump-pistons are all of cast iron, and are each packed with three brass packing-rings sprung into their places.

The engines were to be supplied with steam by two double-flued Cornish boilers, each 20 ft. long by 6 ft. 3 in. in diameter. The boilers were to be worked at a pressure of 55 lb. per square inch, and the engines were intended to run at 45 revolutions per minute, the pumps making 15 double strokes per minute.

SEWAGE PUMPING ENGINES.
 DESIGNED BY MR. W. P. WILKINS, ENGINEER, IPSWICH.
 (For Description, see preceding Page.)



SEWAGE PUMPING ENGINES.
DESIGNED BY MR. W. P. WILKINS, ENGINEER IPSWICH.
(For Description, see Page 601.)



THE SOCIETY OF ARTS.

Is the Society of Arts in such straits for "papers" that their council could provide no other entertainment for the members, on Wednesday week last, than the abortion read by Nicholas Burgh? Or have they no reading and revising committee, and was the rubbish shot upon them unawares? The title was a very brave one—likely to attract a good audience, if any one fit to write upon the subject had been announced. It was "On the Principles that Govern the Future Development of the Marine Boiler, Engine, and Screw Propeller." There can be no question as to the importance and attractiveness of the subject, and, had it been properly dealt with, any paper upon it would have been received with real gratitude to the author. But we should have supposed that the council of the Society of Arts had taken the measure of Burgh long ago, especially as he had inflicted two of his shallowest and most tedious "papers" upon them two or three years since. Burgh occupies the same relation to engineering literature that the poet Close does to poetry. He is an emancipated draughtsman, possessing many well-filled sketch-books, and that unfortunate malady, *cacoethes scribendi*; but he has no idea whatever of natural principles, nor can he write the English language any better than, from an unfortunate physical infirmity, he can speak it—an infirmity to which we should be the last to allude were it not that Burgh is ready to exhibit it wherever and whenever he can get anybody to listen in public to his stammering.

So far from treating of any principles whatever that could govern the future of marine engineering, Burgh bored a small audience with the most atrocious trash that could be concocted; a dissertation filled from beginning to end with blunders, for which a schoolboy would have deserved the birch, and which, had it even been free from these blunders, would have been fit only for an audience of apprentices.

It consisted of three pretended treatises—one upon the marine boiler, one upon the marine engine, and a third upon the screw propeller. Of the first treatise the third sentence is, "To begin, then, I must allude to the quantity of heat in the fuel, and the correct mode of extracting it." And Nicholas "alludes" to it as follows: "The chemical properties of coal are, free carbon, hydrocarbons, water or oxygen, and hydrogen, and solid matter termed ash." We had thought that carbon, &c., were rather constituents than "properties" of coal, that water and oxygen were not equivalent terms, and that there were other solid matters than ash. "In some instances," said Burgh, "the solid matter is 25 per cent., while with superior coal only 6 or 10 per cent." We had thought that in superior coals the solid or cokable matter often amounted to even 90 per cent., and that the other "solid matter," the ash, was often as little as from 1½ to 3 per cent., and that superior coals did not contain from 6 to 10 per cent. of "solid matter" in the form of ash. Burgh will perhaps overhaul Playfair and Delabèche's reports upon British coals, "and when found make a note of." Then, said Burgh, "the products of combustion, according to Professor Rankine, are carbonic acid gas, nitrogen, air, ashes, and steam in the following proportions:

	Value.
Carbonic acid gas	217
Nitrogen... ..	245
Air	238
Ashes	200
Steam	475

Now, we need hardly say that these are *not* the proportions which the products of the combustion of coal bear to each other, making as they do a total of 1.375 with steam, instead of nitrogen, as the principal ingredient. Nor does Burgh attempt to show how this dry tabular statement, even were it correct, instead of being a statement of something altogether different—viz., the specific heats of the gases, as it really is—has anything to do with the "future development of the marine boiler."

Then follows more matter, almost wholly irrelevant and mostly questionable, till we arrive at the statement that "gun metal" of a tensile strength of 36,000 lb. per square inch, "is mostly used for tubes, being next in strength to wrought iron." This is certainly the first we have ever heard of gun metal tubes being used.

The following *morceau* deserves to be reprinted as it stands.

In my own practice, for general purposes, I consider the following proportions of the value of heating surfaces:

Firebox—	Value.
Crown, surface... ..	1,000
Sides above firegrate	500

Combustion chamber—	Value.
Crown and part curved back surface ...	1,000
Tube-plate, effective surface	876
Back (curved)	503
Ends	400
Tubes—	
Total length (if copper)	2,076
(if gun-metal)	25

What Burgh's "practice" is we do not know, nor do we know how he is able to "consider" such precise proportions of the value of heating surface. Nor can "any fellow understand" what is meant by the coefficient appended to "the total length of tubes," the surface of which would appear to be nearly three times as effective as that of any other heating surface in the boiler.

"Here be truths!"

The direct conversion of the water into steam, I believe, is spheroidal, i.e., the water is formed into minute oblate spheres filled with the heat, after which into globes, and thus is passed into what is termed saturated steam; but also bear in mind that the more heat put into the water, or the higher the pressure of the steam, the thinner and smaller will the spheres be, and therefore the lesser saturated the steam. This law is the cause for superheating the steam, and putting a safety-valve on the superheating chamber to prevent an explosion from the further generation of steam in the super-heater.

And here are more truths:

I have shown you in the preceding section that steam is simply composed of heat and water, and you are also aware that the higher the pressure of steam the more heat is put into it. Now, any heat wasted, bear in mind, is actually fuel consumed without effect, which is the reason for steam-jacketing the cylinders. Were there time and space, I would prove to you that the loss of heat by radiation, both with the boiler and engine, is considerable, and that tons of fuel consumed have never performed any duty. To mend this we must work the steam expansively, with high pressures, and simple gear for the cut-off—not to be used as a plaything, but as a requisition of practical value.

And is it for trash like this that our first engineers, to say nothing of admirals, barristers, men of science, and the dilettanti are to be invited to the Society's meetings? Are they to sit under these little lessons at which a stoker's unbreeched boy might rebel, and be told that "steam is simply composed of heat and water," and that "any heat wasted, is actually fuel consumed without effect?" as if the alternative enumeration threw any additional light upon the first? And "were there time and space"—as if the space within the Society of Arts' hall was insufficient—"I would prove to you that the loss of heat by radiation, both with the boiler and engine, is considerable." Verily, Burgh, so it is, but we need no proof of yours, and you need not therefore trouble yourself about "time and space" wherein to prove it. We all knew it long before you did. Nor will this loss by radiation be mended, or lessened, by the means you propose, and which have been so often urged by better men than you, and that before you were born.

Having expressed his views on the combination of "heat and water," Nicholas proceeded to inform his unfortunate audience of the manner in which he considered that combination should be distributed to the cylinder. Said he:

The valve I believe most practical for sea-going engines is the ordinary equilibrium, double-ported valve, of present universal use by the London engineers; and I think our attention, as engineers, knowing the value of a simple motion at sea, should be turned to perfecting this valve and the link motion, rather than running after foreign ideas composed of complicated arrangement and fancifully formed valves.

It is quite possible that Burgh, being a landsman, may occasionally have had "the value of a simple motion at sea" strongly impressed upon his mind, not to say his stomach, but why that should lead him to wish that engineers should devote themselves to perfecting the double-ported valve and the link motion—both details which we thought were thoroughly understood long ago—we really cannot say. By-the-by, if we did see a foreign idea "composed of complicated arrangement and fancifully formed valves," we should be rather inclined to run after it from the curiosity of the thing.

After referring to diagrams, which he stated showed "the slide-valve of the latest proportions," whatever they may be, Burgh gave the following clear explanation of the manner in which the length of the connecting-rod influences the relative positions of the piston and crank. Said Nicholas:

We know that the connecting-rod is a radius, whose arc, intersecting with the centre line of motion, will denote a relative position for the piston, and therefore in no case can the angles of the crank be alike, when the positions of the piston are of equal distances from the ends of the stroke.

The italics are our own; and really we hesitated whether we should not print that portion of the sentence in capitals. It announces a fact hitherto unknown, or at least hitherto unknown to have anything

to do with the length of the connecting-rod. Put in other words, it means that, if the piston is at, say, one-fourth of its stroke from the front end of the cylinder, the crank is not in the same position as if the piston was a similar distance from the back end of the cylinder. May we ask, who—unless it was Burgh—ever thought it was?

We regret that we cannot give some of the valve-motion diagrams referred to in Burgh's paper, in order that the brilliancy of his remarks upon them might be appreciated. The following sentence, however, will serve as a sample:

Now, notice that the length of the chord cutting the circle nearest the valve is shorter than the one opposite; hence the versed sines, &c., are in relation to that circumference, also due to the radius of the circle being unalterable.

This sentence formed part of an elaborately unintelligible disquisition which Burgh entered into to prove the well-known fact that the obliquity of an eccentric rod causes the valve to be drawn towards the crank-shaft; and that this influence increases as the length of the eccentric rod is diminished. Having got at this fact in his own way, Nicholas proceeded to employ a similarly complicated line of what, we presume, he considered argument to prove that the obliquity of the connecting-rod tended to make the periods of admission unequal during the two strokes of the piston; and he stated:

This is the fault with all direct-acting engines, and although the fault may be remedied by unequal laps and leads, the principle of the action remains the same; hence this axiom, "that either lead or expansion must be unequal with direct-acting engines."

Now if Mr. Burgh intends his "axiom" to apply to engines fitted with link motion, as we presume he does, all engineers who have studied the subject know that it is erroneous, as it is quite possible by properly arranging the parts of such a motion to obtain both equal lead and cut-off, if desired. The remedy which Mr. Burgh proposes for the "faux" alluded to in the sentence above quoted is the adoption of what he terms "the return-acting type of engine as far as the position of the connecting-rod and slide-valve are affected." We presume that he means the return connecting-rod type of engine, such as made by Messrs. Maudslay, and we agree with him that the arrangement of such engines enables the link motion to be more readily adjusted, so as to give an equal cut-off; whether, however, this is a matter of much importance, when, as is now almost universally the case, the cut-off is really effected by a supplementary valve, and not by the main slide at all, is another matter.

In support of his views respecting the faults of direct-acting engines, Mr. Burgh gave on an enlarged scale a pair of indicator diagrams, of which he stated:

Each were originally taken from opposite ends of the cylinder, and the difference in the positions of the piston at the points of cut-off termination of expansion and exhaustion, also the variation in the commencement of compression, are faithfully depicted.

We have examined these remarkable diagrams, as reproduced in the *Society of Arts Journal*, and considering that each of them "were" taken from "opposite ends of the cylinder," we have been astonished to find how closely they resemble other diagrams which we have ourselves taken in the ordinary manner.

Considering probably that his audience had been reduced to a state of almost hopeless mental despondency by his reasoning (?), Mr. Burgh kindly endeavoured to reassure them by presenting them with the whole gist of the matter in a condensed form. Said he:

Having proved that the length of the connecting and eccentric rods, lead, and width of opening caused by the valve determines the outside lap of the valve for a given grade of expansion or cut-off, I have condensed this matter into the simplest formula possible, in connexion with my former statements and diagrams. To find the outside lap of the valve for any grade of expansion—divide the radius of the crank by the versed sine of the crank, multiply the quotient by the versed sine of the eccentric; the product, minus the width of the supply opening caused by the valve, equals the outside lap.

In case any of the beauties of this rule should be lost, let us repeat it in another form:

$$\left(\frac{\text{rad. of crank}}{\text{ver. sin. of crank}} \times \text{ver. sin. of ecc.} \right) - \text{width of supply opening} = \text{outside lap.}$$

There! We have placed upon record what, on Mr. Burgh's authority, is the "simplest formula possible" in connexion, it is but right we should add, with his "former statements and diagrams." As we have published this formula, it is possible that some of our readers may feel inclined to write to us to ask what the "versed sine of the crank" may be. All we say to them is, Don't! Let them go to—Nicholas, and inquire. He will probably tell them—if he knows: we can't. We candidly acknowledge our ignorance. We

never knew before that either a crank or eccentric *had* a versed sine; and we may add that we don't know it now, notwithstanding that Mr. Burgh kindly stated, by way of explanation, that

The versed sine of the eccentric is the width of steam supply opening caused by the valve, minus the lead as a rule, but in exceptional cases, as shown, half the lead only.

To be serious, however, is it possible to conceive a more absurd "formula" than that above quoted? In the first place, the grade of expansion does not enter into the formula at all, unless in some way it influences the mysterious quantity which Burgh denominates "the versed sine of the crank." Then again, to be of any use, the rule should give the amount of lap which, if the valve has a given travel, will effect the cut-off at the desired point; but no notice whatever is taken of the amount of travel further than to introduce into the formula the "width of the supply opening"—a quantity which, with a given travel, would be dependent upon the amount of lap, the very thing which the rule is intended to ascertain. If, as Mr. Burgh appears to suppose, the amount of opening of the steam-port and the travel are both known, the lap must evidently be got thus: $\frac{1}{2}$ travel — amount of opening = lap; a more simple rule than Mr. Burgh's "most simple formula possible."

Mr. Burgh concluded his remarks on valve-gear as follows:

With reference to the link motion, I have not time to enter into that subject, but you will be satisfied, I trust, when I state that it can be arranged and proportioned to suit any requirement, which, in a future paper, I will explain.

If that paper is ever read, we pity the hearers.

What have the members of the Society of Arts done to deserve the infliction of such consummate wisdom as this?

I must now direct your attention to the great question of friction, and in so doing I will be as brief as possible. I will set aside, too, the cause of friction, for that I think you all know, and will therefore confine myself to the main effect, viz., the heat generated and the power absorbed. I think the generation of heat from friction is due to electric action, and the mechanical effect is that the atoms of the surfaces of the material in contact are disturbed, and are actually in motion so much as to grate against each other, and thus absorb the power which is required to keep up the speed of motion. I have had full evidence of this with heated bearings, for by strengthening the bolts, and a plentiful supply of spring-water, the two faces were reduced to their normal condition. I therefore permitted the metal to expand, or the atoms to be released from each other, and the cold water absorbed the heat caused by electric action.

Did Burgh ever experience the tickling due to the application of a birch rod to his posterior developments, and did he set down his sensations to "electric action?" And what other explanation of the action of rubbing bodies against each other was ever given than that of the disturbance of the atoms in contact and their grating against each other, as illustrated in the wearing down of unlubricated rubbing surfaces by abrasion, an action capable of being still more visibly demonstrated by a file acting upon soft brass? And let us consider Burgh's special evidence, that which he has had with heated bearings. He "strengthened the bolts"—those, no doubt, holding the halves of the brasses together, and applied "spring water" plentifully! Thames water would not have done at all, nor would *any* water without "strengthening the bolts!" He therefore permitted "the metal to expand, or the atoms to be released from each other, and the cold water absorbed the heat caused by electric action!" Sublime truth! Undoubtedly Burgh was the first to cool a hot bearing by cold water, as he certainly was to attribute its heating to electric action.

Then comes a table of the frictional surfaces of several types of marine engines, calculated in square inches, with not a word as to their respective speeds, or the pressure upon them, or anything that would give the least idea of the friction upon them. A table of the superficial area of the six-sided nuts on the engine, or of the coal-shovels in the stoke-hole would be equally valuable.

The "section" upon the screw-propeller is beneath contempt; for, luckily, while it gives no information of the least value, it has the saving merit that it contains no false statements, and could not, therefore, lead into error any one capable of being led by a Burgh.

The writings of this shallow oracle have been the laughing-stock of both juvenile and adult engineers, long enough at least to have put the Council of the Society of Arts upon their guard. No goose has cackled longer and louder than Burgh; and if he is now to nestle in the straw of the Society of Arts, there to lay his addle eggs, the Society, and not he, will have his absurd quackery fathered upon them. Let him, in all conscience, go on writing his books, and

let those buy and read them who like; but do not again allow an old and respectable institution like the Society of Arts to be lowered in public and professional estimation by such an unworthy performance as that of Wednesday week last.

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. 707, 10d.) John Frederic Brinjes, of Fieldgate-street, Whitechapel, patents arrangements for manufacturing or re-burning animal charcoal, or for distilling shale and similar substances. According to these plans, the materials are placed in a series of horizontal cylindrical retorts, which either revolve continuously in one direction, or have a reciprocating rotary motion given to them. Each retort is provided with a series of internal longitudinal ledges or ribs which serve as lifters for elevating the substance under treatment, and allowing it to descend in the form of a shower towards the bottom of the retort again. As the material descends from these ledges, it is caught by a series of inclined deflecting plates, which are carried by a fixed central shaft within each retort, and these deflecting plates which are adjustable at different angles, deflect the materials towards the discharging end of the retort.

(No. 711, 8d.) William Trimble, of Glasgow, patents methods of preparing vegetable fibres, such as flax, hemp, China grass, &c., for spinning. According to the ordinary method of drawing, the sliver, after passing through the rolls, is received in a can, the end of which was last passed through the rolls becoming uppermost, and this end is passed first through the drawing rollers in the next stage of the operation. According to Mr. Trimble's plan, however, the sliver is drawn continually through the rolls in one direction, the object being to avoid the production of knots or "knavs," by bending or turning back the fibres. The end of the sliver, which is at the bottom of the receiving can, is got at either by turning out the contents of the can into another, or by making the can with two covers. A second part of Mr. Trimble's patent refers to a method of boiling or soaking the fibre, for the purpose of softening it. Instead of winding the sliver, which is to be boiled, round a bobbin or cop, and subjecting it to the action of water or a chemical solution in an air-tight case in the usual way, Mr. Trimble forms the sliver into hanks or skeins, and suspends these in the liquid, so that they are entirely immersed in it. The hanks are strung on rods, and are kept stretched vertically by having rods passed through and suspended by them.

(No. 715, 10d.) Joseph Wilcock, of Stockport, and Samuel Mason, of Manchester, patent improvements in that class of wheel-moulding machines in which the articles are moulded by means of a section or segment of a pattern which is carried by an arm, so that it is capable of revolving around the axis of the wheel which is to be produced. The improvement consists in attaching the arm which carries the section to a radial arm, similar to that of a radial drilling machine, this radial arm also carrying the necessary change and dividing wheels. The radial arm turns on a fixed column as an axis, and the object of the arrangement is to enable the pattern, &c., to be turned on one side, and brought to bear upon a second mould when one is completed.

(No. 718, 8d.) Justin Thèvenet, of Mont-sur-Marchienne lez Charleroy, Belgium, patents a form of equilibrium slide-valve greatly resembling that of Mr. Thomas Adams.

(No. 719, 10d.) John Boyd, of Glasgow, patents improvements in looms, these comprising arrangements for giving tension to the warps as they are drawn off beams or bobbins, and others for taking up the woven fabric. According to these plans the tension is applied to the warps by the application of a weighted bearing-piece upon the surface of the warps on each beam, this bearing piece being connected to a catch gearing with a ratchet wheel, on, or connected with, the beam, and which catch slips a tooth from time to time, in consequence of the drawing off action bringing it into contact with a fixed stop. The chief features in the taking-up apparatus are the application of jointed chains, fitted with pointed pins which take hold of the fabric and draw it up by their movement round a beam or roller, and the arrangement of cams employed for driving these chains.

(No. 720, 8d.) Thomas Walker and Thomas Fer-

dinand Walker, of Birmingham, patent an arrangement of valve gear for reciprocating water-meters, which could not be described without reference to drawings.

(No. 721, 4d.) John Hamilton, of Glasgow, patents producing illuminating gas by the distillation of a mixture of minutely ground or screened bituminous coal, with the tar or pitch resulting from the manufacture of stearine, or other residua of palm oil, or other vegetable distillations. The compound consists of about 20 or 30 gallons of residua mixed with one ton of coal, the intimate combination of the substances being effected in a pug-mill. Mr. Hamilton states that the distillation of the admixture is best effected in a fire-clay retort, at a white heat or thereabouts, the gas given off being treated as ordinary coal gas.

(No. 727, 10d.) John Griffith, of Menai Bridge, patents rigging up a rude form of windmill on board ships for the purpose of working a pump. We do not think that the idea is a *quite* new one.

(No. 728, 10d.) Benjamin Platt, of Liverpool, patents improvement in the manufacture of chloride of lime. According to the process ordinarily followed, chloride of lime is manufactured by placing powdered lime on the floor of a closed leaden chamber, and subjecting it to the action of chlorine gas under a slight pressure. In this method of working it is necessary to shut off the supply of gas occasionally, and to open the chamber for the purpose of turning over the lime so as to expose a fresh surface, the whole of the gas contained in the chamber being lost when it is thus opened. To avoid this loss, and to enable the manufacture to be carried on continuously, Mr. Platt proposes to feed the powdered lime gradually into the top of the chamber, and to allow it to fall through the gas in a zig-zag direction, its course being governed by causing it to pass over a number of inclined shelves with which the chamber is to be fitted. The shelves may be made of glass, and may be either perforated or corrugated. The chamber is to be made higher than usual, and is to have a bottom inclined towards openings through which the chloride of lime can be removed.

(No. 730, 1s.) William Esplen, and James John Briggs Bland, of Liverpool, patent an arrangement of hydraulic signalling apparatus, for affording communication between the bridge of a steam-vessel and the engine-room, and for similar purposes. The apparatus could not be clearly described without reference to drawings; but these we may perhaps give on an early occasion.

(No. 736, 8d.) John Benjamin Dancer, of 43, Cross-street, Manchester, patents a neat indicator for ascertaining the speed of shafting, &c. The apparatus consists of a train of wheel work, which is driven by a friction wheel held in contact with the shaft of which it is desired to ascertain the speed, the train of wheel work giving motion to an index which records the number of revolutions made by the shaft during the time that the friction wheel is in contact with it. There are several neat adjustments about the instrument; amongst others, one for preventing the friction wheel from driving the gearing by its momentum after it is removed from the shafting.

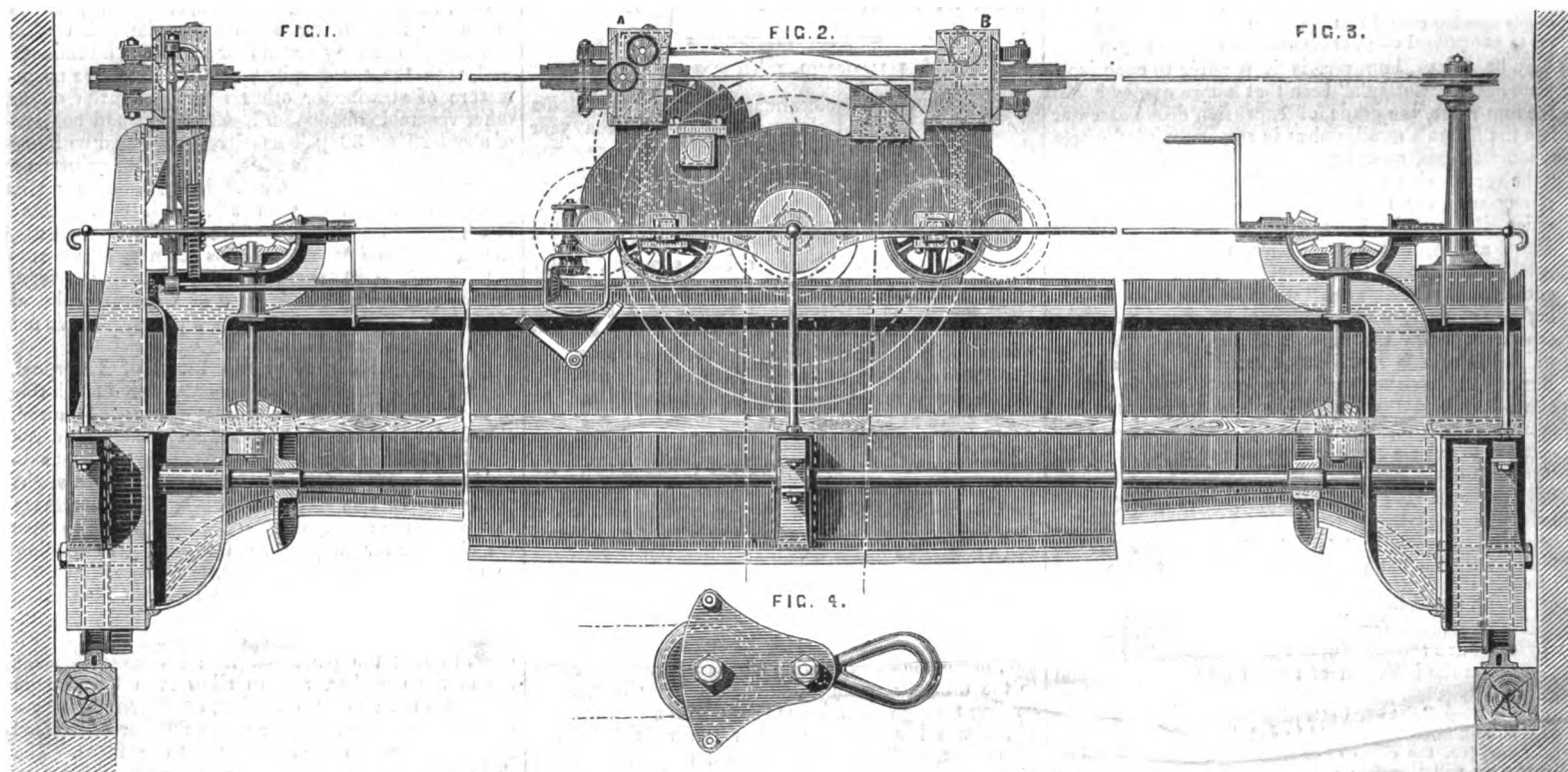
(No. 738, 1s.) Paul Thomas Goodwin, of Camden-street, Camden Town, patents forms of retorts for re-burning animal charcoal. These retorts are of cast iron, and are divided longitudinally into two chambers by a diaphragm or division plate, which may be of various forms. The retorts are each caused to revolve by giving motion to one of the pulleys or roller on which it rests, this roller driving the retort by frictional contact.

(No. 745, 10d.) Joseph Westwood, of Tredegar House, Bow, and Robert Baillie, of Leyton, patent a method of protecting the bottoms of iron ships. According to this plan, flat bars of iron or strips of wood are fixed at suitable distances apart to the outer surface of the ship to be protected, and after these have been coated with black varnish they are covered with a sheathing of wood, which may be afterwards covered with a copper sheathing, if required. The interstices between the skin of the vessel and the wooden sheathing are run in with Portland cement, Roman cement, or a composition made of pitch or bituminous substance, either with or without earthy matter. When a copper sheathing is not used, the wooden sheathing is coated with black varnish or other protecting material.

(No. 753, 10d.) Nathan Thompson, of 15, Abbey-gardens, St. John's Wood, patents a neat form of coupling for connecting the ends of presses or tubes. It would require the aid of drawings to describe the arrangement.

TRAVELLING CRANE AT THE WORKS OF MESSRS. THWAITES AND CARBUTT, BRADFORD.

CONSTRUCTED BY MR. MICHAEL ALCOCK, ENGINEER, WINDSOR BRIDGE IRONWORKS, MANCHESTER.



We give, above, engravings of a well-designed travelling crane of unusually large span and power, which has been recently erected, by Mr. Michael Alcock, of the Windsor-bridge Works, Manchester, at the works of Messrs. Thwaites and Carbutt, the well-known steam-hammer makers and engineers, of Bradford. The crane is made to work by hand power or steam, with all the reversing gear and levers under the control of one attendant, who stands upon a platform between the main girders. The barrel-shaft is hollow, and the second shaft passes through it. The friction-pulleys, worm-wheels, and worms, marked A, command the main chain for hoisting, and the gearing, B, works the traversing movement of the whole crab. The steam power is applied through a quick-running endless cord or flying rope. This crane reaches over a span of 50 ft., and is capable of lifting a load of 50 tons; and it is similar to one which has been erected by the same maker at the works of the Dalton-in-Furness Iron Company.

CONCRETE ARCHES.

TO THE EDITOR OF ENGINEERING.

SIR,—In an article which appeared in last week's *ENGINEERING*, on the Metropolitan District Railway, you allude to an interesting experiment, which is being made by the engineer-in-chief of that line, to test the practicability of constructing concrete arches, of large span, for railway purposes. Experience alone will show how far concrete is suitable for such structures, when exposed to the influence of the weather, in a humid and variable climate like ours. The Romans have already proved that concrete, when used in a dry climate, will make a sound and durable arch.

In the north of Spain several ancient bridges and aqueducts, which owe their origin to those great engineers, are found, and in almost every case concrete was very largely used in their construction. One of the most important of these works is situated close to the old Hermitage of San Gregorio, in the province of Logroño. It is said by the peasantry to have been an aqueduct for conducting water to the Roman town of Calahorra, but they have no tradition of when that portion of it which crossed the river Ebro was carried away. Several of the land arches, on the Navarre side, are still standing, and some of them are *one solid block of concrete*, on which can still be traced the grain of the timber which formed their centres. As evidence of the strength of this work it may be mentioned that one or two of the piers, with half of each of the arches which they supported still attached to them, are lying on the ground, and were not fractured or broken by the fall. One of the abutments of this interesting work is still standing. It was built of stone and blocks of concrete laid in alternate courses.

In some cases arch sheeting and spandril walls were built with a very bad class of stone, principally round field boulders, but all the backing was concrete. From the rough nature of this work, and the unsuitable character of the stones used for turning an arch, it would naturally suggest itself that the Roman engineers used the stone more with the object of protecting the concrete from the scour of the water, and the influence of the weather, than to add any real stability to the work. In the case of the San Gregorio aqueduct, the Romans clearly showed their preference for concrete, as abundance of good stone, easily worked with the bar only, is found in the hills within a few yards of the concrete arches referred to.

I am, Sir, yours truly,
Westminster, December 24, 1867. J. P. ROBERTS.

THE "SHIP OF THE FUTURE."

TO THE EDITOR OF ENGINEERING.

SIR,—In my letter of 6th instant, I stated that the "ship of the future" was one and the same with that in connexion with which Captain Henry Randall, of New York, secured some patents respecting the strengthening of the hull and the position of the paddles. From the drawings I had the pleasure of leaving at your office, you will observe that the proposed vessel is to be worked or moved by four paddles; that each set of paddles is to have separate engines, so that, in the event of the machinery connected with one getting into disorder or disabled, there will be still nearly as much propelling power left as ordinary steamers have. You will also notice that the rear paddles are of considerably greater circumference than the forward, and the reason assigned for this is that they will thus be more effective in the slack water caused by the latter. The distance to separate the paddles is stated at 150 ft. as giving the greatest efficiency. American engineers, shipbuilders, and captains are unanimous in commending this arrangement, as well as in their high appreciation of the strengthening power of the arch, which you will perceive from the drawing to be such as to prevent the possibility of the vessel's breaking her back—a liability to which long vessels are said to be peculiarly open. The separate iron bulkheads, which form so conspicuous and valuable a feature in the Great Eastern, will also be found in the Randall ship. In short, the proposed boat will be a ship within a ship. Dispensing with masts, and drawing considerably less water than is now supposed to be the orthodox thing, she will, with much less coal, obtain much greater speed than is now attained by the fastest ocean steamers, and require only a fractional part of the crew now thought necessary to man a vessel thoroughly. Prejudice will be hard to fight; it always is a stumbling-block in the way of genius; but a gentleman like Captain Randall, who has spent fifteen years or more in perfecting his models, is not likely to be daunted by coldness or opposition. He offers the public a vast improvement upon the present method of ocean transit, and the public will eventually, no doubt, appreciate his efforts in their behalf, and give him a helping hand. The scarcity of available money at present and since the war prevailing in the United States alone gives the British people the opportunity of having under the "Union Jack" a class of vessels which would otherwise be showing the "Stars and Stripes," and which, in the opinion of excellent judges, are destined to control, in the future, the ocean traffic of the world. Shipbuilders here may lack courtesy, or their clerks may be guilty of making them open to this charge, but if their interest is to be found in the adoption of this description of marine architecture, they will, no doubt, encourage Captain Randall, irrespective of professional jealousy. Much has to be done to effect this, and chief among the instruments in accomplishing it must be the able and unprejudiced advocacy, even discussion of it, by the able pens and subtle brains that write for and to *ENGINEERING*.

The probable cost of the Randall ship would be not over 200,000*l*. An immense amount certainly, but one, I consider, beyond the requirements. The vessel would carry across the Atlantic, say, 900 first-class passengers from Liverpool to New York in *six days*, 1600 second-class, whose accommodation would be as far in advance of that now obtained in the best steamers afloat as that is better than any which prevailed in small sailing ships of bygone days. In addition to the passengers, there would be stowage for 5000 tons of goods.

Individuals many remark, "But where is all this traffic to come from?" I answer, give the public the comforts of a hotel, with almost entire immunity from sea-sickness, with perfect security, and the facilities for it will draw the traffic. Rates, too, would be greatly reduced, and this would be an additional inducement to travel. *Nationally*, in addition to being the owners of the fastest, safest, and most commodious boats in the world, the establishment of them would set such a current of travelling to and from America going as would greatly help to make the two peoples understand and appreciate each other and their countries better, and thus be an additional guarantee for peace and goodwill between them. It is a positive, an undeniable fact that it is the want of acquaintance with each other's greatness which engenders the eternal bickering and squabbling which seems chronic now.

Will any one undertake to say that, apart from the Irish agitators who have done so much mischief, the influence of the entertained opinions of intelligent tourists to Europe and America has not greatly tended to maintain harmony, and do away with bitter feelings, the result of ignorance of the real sentiments of one towards the other? I venture to say that Charles Dickens's visit will do more good than the presence of twenty mere ambassadors in the United States. By all means let us cultivate each other, and we can do it now only by dribblets; let us try the Randall ship. 200,000 individuals, with the heart to embark a sovereign each in the construction of the innovation, would establish a principle which may be of incalculable value. It is not individually a large amount, although the aggregate is; and the proposal may—nay, no doubt, will—be considered absurd.

In conclusion, thanking you for the insertion of my last letter, begging the same favour for this one, I would remark that Captain Randall is known, celebrated for the style of comfort and elegance of his saloons and state-rooms.

Believe me to remain, yours faithfully,
London, December 17, 1867. CAMPBELL ROSS.

THE METROPOLITAN RAILWAY.—A circular has just been issued to the shareholders of this company by the chairman, Mr. J. Parson, and Mr. C. Gilpin, M.P., deputy-chairman, stating that the recent fall in the prices of Metropolitan stock is not believed to be due to any widespread distrust of the intrinsic soundness of the undertaking, nor to be the result of genuine business transactions; but to have been caused solely by the operations of a combination of speculators, whose only aim has been a temporary depression in the market value of the stocks. Articles in newspapers, pamphlets, anonymous letters, advertisements threatening legal proceedings, are all parts of the machinery which has been set in motion to induce the shareholders to sell their stock, under the influence of panic, at a depreciated price. It is, therefore, considered right to warn them that, so far as the executive can perceive, the present position of the Metropolitan Railway affords no cause for apprehension, but on the contrary there is in every respect matter for congratulation. There is no reason to fear a diminution of dividend, nor to doubt the accuracy of the estimate of future revenue, nor to apprehend excess in the cost of the works in hand, or any necessity for raising additional capital. Hitherto the shareholders have not parted with their stock, the transfers have been less than usual, both in number and amount. Under these circumstances the shareholders have only to refrain from parting with their property to defeat the combinations to which reference has been made, and to see the market value of the stocks speedily return to what they were before the operations commenced.

NON-CIRCULATING

